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Volatility and Leverage: an Analysis of Latin American Companies

ABSTRACT

Objective: To analyze the relationship between the leverage level and the volatility of Latin American stocks, from January 2005 to June 2020.

Method: A multiple linear regression was used, with the coefficients estimated by the GMM and with the data arranged in a panel. Volatility was estimated by the EGARCH model and six leverage measures were used.

Originality/Relevance: The study analyzes the relationship between volatility and leverage in the context of Latin America and shows that periods of crisis can affect this relationship. The results are relevant for managers, who can strategically adjust the degree of leverage in order to maximize the company's value for shareholders, and also for investors, as it allows for a better alignment between their risk profile and the desired return.

Results: The results indicate that there is a positive relationship between the degree of leverage of the firm and the volatility of assets. It was also found that, in periods of crisis, even if companies reduce their leverage levels, volatility will tend to increase due to the uncertainties related to these periods.

Theoretical/Methodological Contributions: In the analysis of the relationship between leverage and volatility, the moderating effect of periods of crisis was also verified and the endogeneity between the variables was considered through the GMM. In addition, volatility was estimated using the EGARCH model, which considers volatility asymmetries, with results controlled by corporate and macroeconomic variables.

Key words: Volatility, Leverage, Crisis, EGARCH, GMM.

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1 INTRODUCTION

The volatility of stocks consists of fluctuations in the prices of assets, so their analysis allows the identification of their degree of risk. Therefore, volatility is relevant for managers, investment agencies, and individual investors since its analysis allows, for example, the pricing of assets and the measurement of risks, helping to adjust risk and return according to investor profile. In this sense, in addition to being influenced by macroeconomic factors, volatility can also be affected by company-specific factors, as well as by investor behavioral issues (Kim & Won, 2018; Markowitz, 1952; Mittnik et al., 2015; Thampanya et al., 2020).

On the other hand, capital structure concerns a topic discussed over the years in the finance literature, mainly based on the studies by Modigliani and Miller (1958, 1963), who analyzed the relationship between debt and firm value. However, even with the advances in the area, especially from the trade-off theory, with the consideration of taxes and bankruptcy costs and the pecking order theory, with the priority in the use of resources, there is still no consensus on the factors that determine the ideal capital structure. On the other hand, some studies indicate that the specific characteristics of the firm and the country, such as macroeconomic and institutional ones, influence companies' leverage decisions (Belkhir et al., 2016; De Jong et al., 2008; Kayo & Kimura, 2011; Myers, 1984; Myers & Majluf, 1984).

Furthermore, both variables are characteristic of occupying a central role during periods of instability in the markets. Regarding volatility, it is known that it can behave differently during periods of recession or expansion since shocks (such as the one that occurred with the subprime crisis in 2008) can be transmitted to other markets through the contagion effect (Hwang et al., 2013; Mittnik et al., 2015). Furthermore, the degree of leverage, in turn, also stands out during financial crises, considering that more indebted companies tend to take greater market risk and be more susceptible to environmental instabilities (Alaoui et al., 2017; Reinhart & Rogoff, 2010). In this sense, when company

managers decide to increase the firm's leverage level, it is expected that the stock return volatility (SRV) will increase, considering that this attitude may indicate, for the market, an increase in the probability of the firm faces financial difficulties, which creates uncertainty for shareholders (Engle & Siriwardane, 2018; Myers, 1977).

Thus, considering that emerging markets receive capital flows from foreign investors to benefit from the growth of these markets, which tend to be more volatile (Bekaert & Harvey, 1995), and based on the studies by Alaoui et al. (2017), Belkhir et al. (2016), Engle and Siriwardane (2018) and Thampanya et al. (2020), this research aims to answer the following question: What is the relationship between corporate leverage and volatility of financial assets? Because of this, the following objective was established: to analyze the relationship between leverage and the volatility of the shares of companies in Latin America, considering the period from January 2, 2005, to June 30, 2020. Notably, the Latin American countries comprising the sample are Brazil, Chile, and Mexico, which were selected due to the data availability for estimating the volatility of the EGARCH model.

This study contributes to the advancement of theory by using the EGARCH technique to estimate volatility, unlike previous studies, such as Alaoui et al. (2017), which calculated it with the standard deviation of returns. This study analyzed the moderating effect of periods of economic crisis on the relationship between leverage and volatility. Furthermore, the results were also controlled by macroeconomic and corporate variables, unlike Engle and Siriwardane (2018) and Mittnik et al. (2015) and Thampanya et al. (2020), who did not consider the effects of debt and firm size on volatility. Endogeneity problems between variables were also considered using the Generalized Method of Moments (GMM). It should be noted that the analysis of the relationship between the investigated variables is largely unexplored by the finance literature (Alaoui et al., 2017; Engle & Siriwardane, 2018).

It is important to note that the results can help managers decide about the ideal leverage level for the company, considering the effects of this variable on volatility, which can help maximize shareholder value. In addition, the results allow individual investors and investment agencies to more optimally align the risk level of the asset and the desired return, considering the firm's leverage, other corporate variables, macroeconomic conditions, and the crisis periods. In turn, the analysis of the volatility of assets in Latin America also helps economic agents in the decision-making process of investing their resources in these markets.

2 LITERATURE REVIEW

2.1 Stock volatility

Volatility refers to fluctuations in asset prices and is thus associated with their degree of risk, according to Kim and Won (2018). Considering these oscillations, Markowitz (1952) presents the composition of portfolios based on risk and return levels, intending to obtain the set of assets that provides the most efficient results. In this way, the analysis of the volatility of the assets that make up a portfolio reflects the risk of the portfolio, proving to be relevant for pricing securities and risk management (Kim & Won, 2018; Markowitz, 1952).

In addition to the ability to reflect risks, the behavior of volatility is also associated with the stock returns themselves. According to Black (1976) and Christie (1982), stocks with negative returns, for example, tend to show greater volatility in future periods. The authors justify this phenomenon, stating that the reduction in equity of companies leads to an increase in leverage and, consequently, an increase in risk. In this sense, studies indicate financial leverage as one of the factors responsible for the asymmetry in volatility.

Another aspect that can influence volatility is the expected risk premium. According to French et al. (1987), who analyzed US common stocks, there is a positive relationship between volatility and the expected risk premium, indicating that the premium is also one of

the factors that cause the asymmetry in the volatility of securities. In addition, unexpected positive increases in bond price volatility lead to increases in the expected risk premium and lower current asset prices.

To define the factors that influence volatility, Schwert (1989) analyzed the relationship between stock volatility and macroeconomic volatility, financial leverage, and stock trading activity. According to the author, leverage has a small explanatory effect on stock volatility, so when the company increases the proportion of debt securities concerning its equity, volatility tends to increase, corroborating Black (1976) and Christie (1982). Furthermore, asset volatility would have the ability to predict future macroeconomic volatilities because volatility reflects new economic information.

In line with Schwert (1989), studies such as Poon and Taylor (1991), Errunza and Hogan (1998) and Mittnik et al. (2015) indicate that macroeconomic factors affect the volatility of assets, such as, for example, the Gross Domestic Product (GDP), the inflation rate and the exchange rate, since these factors are considered in the decision making of shareholders. In addition, factors intrinsic to companies, such as revenue, assets, and liabilities, as well as indicators such as return on equity (ROE) and return on assets (ROA), are also related to market fluctuations, as pointed out by Corradi et al. (2013) and by Guo and Savisckas (2008).

In addition to fundamental business factors and macroeconomic variables, behavioral factors also have the potential to explain volatility. Smales (2016), for example, points out that aggregate news sentiment has a negative relationship with implied volatility, and this relationship is asymmetrical, proving to be stronger when it comes to negative news. Thampanya et al. (2020) also find results similar to those pointed out by Smales (2016); however, the authors used emerging countries as a sample. They concluded that shareholder

behavioral factors may exert a greater influence on volatility when compared to macroeconomic and corporate factors.

In this sense, the location of assets can also influence the fluctuation of asset prices. When analyzing emerging and developed countries, for example, it is noted that these have specific characteristics in terms of volatility, showing notable differences in market behavior. It should be noted that the difference in emerging markets occurs mainly in times of reforms in the stock market. In addition, more open economies tend to have lower levels of volatility and a greater correlation with the world market (Bekaert & Harvey, 1995; Thampanya et al., 2020).

2.2 Corporate leverage

Based on the assumption that companies can benefit from increases in leverage due to tax benefits (Modigliani & Miller, 1963), theories were developed that contradict these studies, pointing out that the form of financing is related to the value of the firm, and may highlight the pecking order and trade-off theories. According to Myers and Majluf (1984), companies prefer using resources from internal sources for self-financing and seeking external resources, that is, from third parties. If the firm needs extra funding, preference will be given to sources that minimize the risk of information asymmetry, with the issuance of new shares being the last option.

Myers (1984) presents the optimal capital structure, pointing out that companies must balance their debt and equity, considering the effects of taxes and bankruptcy costs. Still, according to this theory, more diversified companies have less variation in their operational flow, making it easier to obtain financing. In addition, there is a tendency for more profitable companies with more tangible assets to use fewer third-party resources; thus, higher debt

levels lead to better discipline and more caution on the part of managers (Brealey et al., 2006; Welch, 2004).

Based on the study by Titman and Wessels (1988), the research sought to identify the factors that influence companies' leverage levels, pointing out that companies have specific factors that affect their financing decisions. In addition, the authors assert that the characteristics of each country and macroeconomic factors are also related to the capital structure of companies (Belkhir et al., 2016; Booth et al., 2001; De Jong et al., 2008; Kayo & Kimura, 2011).

As a result, in addition to the factors inherent to the business itself, as well as the macroeconomic indicators, as mentioned above, there is evidence that geographic location, such as economic blocks, and social and political factors also reflect on capital structure decisions, as teach Belkhir et al. (2016), De Jong et al. (2008) and Gwatidzo and Ojah (2014). In addition, the sector of the economy also influences the firm's leverage, given that the companies that comprise it have characteristics in common, such as assets and average leverage, with managers tending to make similar decisions regarding financing (Leary & Roberts, 2014; Li & Islam, 2019; Oliveira & Kayo, 2020).

In Latin America, Martins and Terra (2014) analyzed the factors that affect the leverage of companies and found that the variables profitability, liquidity, tax burden and inflation have a negative relationship with the indebtedness of companies, while size, GDP, tangibility, and the interest rate have a positive influence. The authors also point out that companies that operate in sectors with greater availability of capital tend to use lower levels of third-party capital. Furthermore, Bernardo et al. (2018) found that the variables that represented the characteristics of the companies have the greatest potential for explaining the variation in leverage. In addition, the authors point out that GDP has a negative relationship with leverage, which disagrees with Martins and Terra (2014).

2.3 Leverage and volatility

Based on the trade-off theory, companies that make decisions to increase their leverage are subject to higher bankruptcy costs and an increased probability of default due to the cost of third-party capital and the risks involved (Myers, 1984). With this, it is expected that the volatility of stock returns will tend to increase since shareholders will be more insecure about the company's future (Chelley-Steeley & Steeley, 2005; Christie, 1982; Smith & Yamagata, 2011).

In this sense, several studies have sought to analyze the relationship between indebtedness and asset behavior, such as Cai and Zhang (2011), who categorized ten portfolios composed of American companies based on the variation in the leverage ratio. According to the authors, portfolios with greater leverage ratio increases tend to have lower stock returns. The most likely reason for this effect is a possible increase in the risk of default caused by the increase in debt compared to the company's total assets (Myers, 1977; Myers, 1984; Schwert, 1989).

In addition to increases in the degree of leverage resulting in lower returns (Cai & Zhang, 2011), Chelley-Steeley and Steeley (2005) indicate that these increases are also related to greater asymmetries in the companies' SRV. The authors used UK companies as a sample and pointed out that smaller companies have higher leverage ratios when compared to larger companies. According to the study, this would be why smaller companies are more susceptible to the leverage effect (Smith & Yamagata, 2011).

Engle and Siriwardane (2018) use American companies as a sample, in the period of the 2008 crisis, in the context of the Troubled Asset Relief Program (TARP) developed by the US government. The authors proposed the Structural GARCH model and concluded that the capital injection by the Bank of America Corporation (BAC) reduces the volatility of equity

returns and the probability of bankruptcy of these companies, according to the magnitude of this capital injection. This result, although obtained based on a specific context, may also indicate that changes in the capital structure may be related to the volatility of the shares since the mentioned capital injection allowed the reduction of equity volatility. Thus, the risk perception of shareholders could be lower.

In turn, Alaoui et al. (2017) analyzed companies in Europe, finding differences in the effects of changes in leverage on the volatility of those companies. The authors found that companies with higher debt levels tend to increase their volatility when they increase their leverage. However, companies with lower debt levels tend to decrease their volatility by increasing their leverage. This difference occurs because companies with lower debt ratios tend to be smaller; therefore, increases in leverage may indicate new investments and increased growth prospects (Chelley-Steeley & Steeley, 2005; Smith & Yamagata, 2011). Considering the exposed evidence, this research establishes the following hypothesis:

Hypothesis: There is a relationship between the degree of leverage and the volatility of the shares of Latin American companies.

3 METHODOLOGY

3.1 Data and sample

This research analyzes the relationship between volatility and leverage in Latin American publicly traded and non-financial companies. The study will focus on Brazil, Chile, and Mexico companies from January 2, 2005, to June 30, 2020. The initial sample comprises 517 companies. A liquidity filter was carried out to exclude companies whose shares did not trade during the entire analyzed period or did not present the necessary liquidity for estimating volatility by the EGARCH model. As a result, the final sample consists of 63 Latin American companies, 28 Brazilian, 13 Chilean, and 22 Mexican.

The choice of countries analyzed in the research was because they are the most developed markets in Latin America and, therefore, have greater liquidity of traded shares since the liquidity of the asset and the absence of missing values in the price series are requirements of the EGARCH model. In addition, the countries still stand out for representing approximately 60% of Latin America's GDP, according to data from the World Bank (2020).

The analysis period was selected to cover periods of stability and instability in the sampled markets, which allows the identification of possible relationships between volatility and leverage. In this sense, according to the International Monetary Fund (2020), for example, per capita GDP in Latin America went through a period of growth until 2013, driven by commodities, even considering the 2008 subprime crisis. , from 2014, there was, on average, a decrease of 0.6% per year, reaching the stagnation of economic activity in 2019, mainly motivated by low levels of investment added to the political and economic uncertainties of countries region, such as Brazil and Mexico. In addition, the first two quarters of 2020 were characterized by the impacts of the pandemic caused by the SARS-CoV-2 virus.

As for the data, the collection was carried out on the Thomson Reuters platform, in which the daily quotations of the shares were obtained, as well as the economic and financial data of the companies, in dollars, with a quarterly frequency. Macroeconomic data of the countries that make up the sample were also collected quarterly, such as GDP, inflation rate, interest rate, and money supply, which were obtained from the following sources: Brazilian Institute of Geography and Statistics (IBGE), Central Bank of Brazil (BCB), National Institute of Statistics (NIS), Central Bank of Chile (BCC), the Mexican National Institute of Statistics and Geography (INEGI) and Bank of Mexico (BdeM).

3.2 Method

The exponential GARCH model (EGARCH) was used to estimate the volatility of stock returns. According to Mittnik et al. (2015) and Thampanya et al. (2020), the EGARCH measure is adequate since, in addition to capturing volatility and leptokurtosis clusters, as in the ARCH and GARCH models (Bollerslev, 1986; Engle, 1982), it considers volatility asymmetries, that is, it does not have the restriction of non-negativity of the values of the coefficients of its conditional variance equation (Nelson, 1991).

Thus, Equation 1 represents a time series, where X represents the explanatory variable, and M represents the parameter and ε the error. The EGARCH model (1, 1) was used to estimate the conditional variance from the daily log returns of the stocks, as shown in Equation 2, where σ_t^2 represents the conditional variance, ω the intercept, α the volatility reaction, λ the asymmetry, and β the persistence. The volatility estimates were then transformed to quarterly frequency by taking the average values within each period.

$$R_t = X_t M + \varepsilon_t \quad (1)$$

$$\ln(\sigma_{t+1}^2) = \omega + \alpha\left|\frac{\varepsilon t}{\sigma t}\right| + \lambda\frac{\varepsilon t}{\sigma t} + \beta\ln(\sigma_t^2) \quad (2)$$

The stationarity of the price series was confirmed by performing the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PF) unit root tests. In case of divergence between the tests regarding the indication of stationarity, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test was performed, which confirmed that the series is stationary. Next, stock returns were regressed with lags of up to ten previous days to find the best fit for each sample price series. In addition, the ARCH-type test was performed on the residuals, with 12 lags, to verify the presence of heteroscedasticity. This test was performed before and after carrying out the EGARCH model to confirm that the problem was solved.

Outliers were treated by the winsorizing method at the 5% level. Furthermore, using the Stata software, multiple linear regression with panel data was used as a technique for data analysis, with its coefficients estimated by the Generalized Method of Moments (GMM) (Two-Step System), suggested by Arellano and Bond (1991) and also used by Alaoui et al. (2017). The instruments used were the first difference of the variables Interest rate, Inflation rate, Money supply, Stock market return, Dummy for periods of crisis, and Dummy for the country (Alaoui et al., 2017; Arellano & Bond, 1991).

GMM was used to analyze the relationship between volatility and leverage, as there are signs of endogeny between the variables mentioned since studies point to a possible reverse causality (Ahmed & Hla, 2019; Alaoui et al., 2017). Furthermore, the two-step GMM was selected because, although one-step models are already consistent, the second step tends to be more asymptotically efficient (Alaoui et al., 2017; Antoniou et al., 2008; Arellano & Bond, 1991). This model has advantages over others, such as OLS with fixed or random effects, since it attenuates or eliminates possible endogeneity problems between the variables by considering sequential exogeneity regressors. (Baltagi, 2005; Blundell & Bond, 1998; Roodman, 2009). It should be noted that using several variables in financial statements is also potentially a source of endogeneity (Baltagi, 2005; Roodman, 2009).

In addition, to verify the presence of multicollinearity in the model, the Variance Inflation Factor (VIF) test was performed, using a VIF lower than ten as a parameter, according to Gujarati and Porter (2011). Table 3 shows the highest VIF value for each model. As a result, it was found that there is no multicollinearity between the variables in models 2 to 6 since the VIF value was less than 10; however, model 1 presented a VIF value of 11.11, but it was chosen for keeping it since it is a model with moderation and the correlation matrix (Table 2) did not indicate multicollinearity between the variables (Disatnik & Sivan, 2016). The presence of autocorrelation was verified using the Wooldridge test, and the Wald test was

performed to verify the presence of heteroscedasticity and, to correct these problems, standard errors were corrected using the Windmeijer (2005) method (Baum & Christopher, 2006; Fávero et al., 2009; Stock & Watson, 2003; Wooldridge, 2016). In addition, to verify the model specification, the Sargan and Arellano Bond (AR) tests were performed (Alaoui et al., 2017; Arellano & Bond, 1991; Blundell & Bond, 1998).

3.3 Study variables

In Figure 1, the variables used in the study are presented so that the dependent variable of the first model is the SRV, while the variables of interest are the leverage measures. The model was constructed from studies by Alaoui et al. (2017), Feng et al. (2017), Mittnik et al. (2015), and Thampanya et al. (2020).

The Crisis variable was considered a crisis period for the three countries, the years 2008 and 2009, characterized by the subprime crisis, and the first two quarters of 2020 due to the Covid-19 pandemic. In addition, the years 2015 and 2016 were considered a period of crisis for Brazil, so in those years, the country's GDP fell by 3.6% and 3.4%, respectively, due to public policy errors that led to an increase in the fiscal cost and supply and demand shocks (Barbosa Filho, 2017; IMF, 2021; Ocampo, 2009; Singer, 2009).

The econometric model (1) used in the study is presented below, where ALAV represents the leverage measures used, "i" represents the company, "t" represents the quarter, β_0, the intercept, β_1 to β_9 represents the coefficients of the variables explanatory, ω represents the dummy variable for the country, and ε, the error.

$$VRA_{it} = \beta_0 + \beta_1(ALAV_{it}) + \beta_2(Crise_t) + \beta_3(TAM_{it}) + \beta_4(ROE_{it}) + \beta_5(PIB_t) + \beta_6(TXJ_t) + \beta_7(INF_t) + \beta_8(OM_t) + \beta_9(RMA_t) + \omega + \varepsilon_{it} \quad (1)$$

Figure 1

Econometric model variables

Variable	Acronym	Calculation	Authors
Dependent variable			
Stock return volatility	SRV	EGARCH (Daily values converted to quarterly)	(1) and (2)
Variáveis de interesse			
Total accounting leverage	ALAVCT	(Current Liabilities + Non-Current Liabilities) / (Total Assets)	(3), (4) and (5)
Total market leverage	ALAVMT	(Current Liabilities + Non-Current Liabilities) / (Total Liabilities + Market Value of Equity)	(4) and (5)
Long-term accounting leverage	ALAVCLP	Non-current liabilities / Non-current liabilities + Equity	(3) and (6)
Long-term market leverage	ALAVMLP	Non-current liabilities / (Non-current liabilities + Market value of shareholders' equity)	(3), (6) and (7)
Accounting leverage 2	ALAVD	Total Debt* / Total Assets	(4) and (12)
Short term leverage	ALAVCP	Current assets / Total assets	(12)
Dummy for periods of crisis	Crisis	Dummy variable, where 1 represents crisis periods.	
Control variables			
Firm size	SIZE	Operating income / Total assets	(8)
Return on equity	ROE	Return on equity	(8), (2) and (9)
GDP growth	GDP	GDP growth rate	(2) and (4)
Interest rate	TXJ	Country interest rate	(2) and (10)
Inflation rate	INF	Growth rate of the Consumer Price Index	(1), (10) and (11)
Currency offering	OM	Country currency offer**	(1) and (2)
Stock market return	SMR	Quarterly return of the country's main index	(1) and (10)
Dummy for country	COUNTRY	Dummy variable for country	

Note. * Total debt is represented by the sum of short- and long-term onerous liabilities. ** Indicates the amount of money in circulation in a given country. Authors: (1) Mittnik et al. (2015); (2) Thampanya et al. (2020); (3) Booth, Aivazian, Demirguc-Kunt and Maksimovic (2001); (4) Belkhir et al. (2016); (5) Li and Islam (2019); (6) Kayo and Kimura (2011); (7) De Jong et al. (2008); (8) Gaspar et al. (2006); (9) Alaoui et al. (2017); (10) Feng et al. (2017); (11) Guo and Savisckas (2008); (12) Bernardo et al. (2018). Source: Elaborated by the authors.

4 RESULTS PRESENTATION

In this section, the results obtained from the research are presented. Table 1 shows the descriptive statistics of the variables used in the study after treating the outliers.

Table 2 presents the Spearman correlation between the research variables. It was also verified, in this Table, the statistical significance of the correlation obtained.

Table 1

Descriptive statistics

Variable	Comments	Average Brazil	Average Chile	Average Mexico	Total Average	Standard deviation	Minimum	Maximum
ALAVCT	3,904	0.640	0.554	0.563	0.595	0.186	0.190	1.064
ALAVMT	3,904	0.573	0.452	0.317	0.459	0.243	0.002	0.997
ALAVCLP	3,904	0.527	0.440	0.456	0.484	0.216	0.057	1.047
ALAVMLP	3,904	0.479	0.351	0.242	0.370	0.247	0.002	0.990
ALAVD	3,904	0.312	0.293	0.265	0.291	0.150	0.000	0.628
ALAVCP	3,904	0.238	0.205	0.204	0.219	0.109	0.012	0.545
SRV	3,844	0.00112	0.00040	0.00057	0.00077	0.00074	0.00000	0.00395
SIZE	3,717	20.672	20.484	20.796	20.684	1.283	17.708	23.397
ROE	3,750	0.041	0.031	0.042	0.039	0.046	-0.049	0.156
GDP	3,906	0.400	0.715	0.396	0.464	1.242	-4.077	2.527
INF	3,906	0.425	0.274	0.329	0.360	0.263	-0.217	0.964
TXJ	3,906	10.965	3.702	5.835	7.675	4.143	0.500	19.667
OM	3,906	0.667	0.943	0.654	0.719	2.564	-6.717	5.586
SMR	3,843	0.030	0.015	0.020	0.023	0.133	-0.361	0.322

Source: Prepared by the authors.

Table 2

Correlation matrix

	VRA	ALAVCT	ALAVMT	ALAVCLP	ALAVMLP	ALAVD	ALAVCP	TAM	ROE	PIB	INF	TXJ	OM	RMA	Crise
VRA	1														
ALAVCT	0.3695*	1													
ALAVMT	0.3702*	0.4777*	1												
ALAVCLP	0.2972*	0.7275*	0.3862*	1											
ALAVMLP	0.3639*	0.4669*	0.9230*	0.5058*	1										
ALAVD	0.1420*	0.6255*	0.3167*	0.6005*	0.3360*	1									
ALAVCP	0.2028*	0.6493*	0.3113*	0.1253*	0.1109*	0.2735*	1								
TAM	-0.1698*	0.1333*	0.0121	0.2795*	0.0557*	0.2507*	-0.0522*	1							
ROE	-0.1656*	0.0246*	-0.1190*	-0.0360*	-0.1027*	-0.0350*	0.0301*	0.1674*	1						
PIB	-0.3064*	-0.0778*	-0.0086	-0.0621*	0.0020	-0.0749*	-0.0384*	-0.0125	0.0528*	1					
INF	0.0944*	0.0680*	0.0049	0.0418*	0.0027	0.0312*	0.0610*	0.0503*	0.0260*	-0.0299*	1				
TXJ	0.3981*	0.2050*	0.0808*	0.1247*	0.0712*	0.0831*	0.1914*	0.0718*	0.0434*	-0.0969*	0.3354*	1			
OM	-0.1648*	-0.0224*	-0.0028	-0.0188*	0.0035	-0.0236*	-0.0029	-0.0303*	0.0146*	0.2730*	-0.0825*	0.0246*	1		
RMA	0.1831*	0.0158*	0.0056	0.0056	0.0090	-0.0008	0.0233*	-0.0237*	-0.0007	0.0308*	-0.2193*	0.0777*	0.0589*	1	
Crise	0.4191*	0.0633*	0.0672*	0.0317*	0.0576*	0.0518*	0.0611*	0.0043	-0.0171*	-0.3103*	0.0782*	0.2323*	-0.0567*	0.1341*	1

Note. * indicates significance at the 5% level. Source: Prepared by the authors.

Table 3 presents the results obtained from the GMM, with panel data, which aimed to identify the effect of leverage on volatility. In the next section, the results of Table 3 are analyzed based on the ceteris paribus principle.

Table 3

Influences of leverage on volatility

Model Y	1 SRV	2 SRV	3 SRV	4 SRV	5 SRV	6 SRV
ALAVCT	0.0043***					
	(6.09)					
ALAVCT x Crisis	-0.0024***					
	(-3.73)					
ALAVMT		0.0026***				
		(9.41)				
ALAVMT x Crisis		-0.0012***				
		(-4.84)				
ALAVCLP			0.0031***			
			(5.49)			
ALAVCLP x Crisis			-0.0015***			
			(-3.38)			
ALAVMLP				0.0024***		
				(9.32)		
ALAVMLP x Crisis				-0.0011***		
				(-4.91)		
ALAVD					0.0022***	
					(5.55)	
ALAVD x Crisis					-0.0008*	
					(-1.89)	
ALAVCP						0.0026***
						(5.93)
ALAVCP x Crisis						-0.0017***
						(-3.75)
Crisis	0.0017***	0.0009***	0.0011***	0.0007***	0.0006***	0.0007***
	(4.18)	(6.21)	(4.41)	(7.20)	(4.19)	(6.90)
SIZE	-0.0001	-0.0001***	-0.0001***	-0.0001***	-0.0001**	-0.0000
	(-1.40)	(-2.98)	(-3.01)	(-3.16)	(-2.50)	(-1.10)
ROE	-0.0009***	-0.0013***	-0.0009***	-0.0012***	-0.0014***	-0.0020***
	(-3.03)	(-3.79)	(-3.12)	(-3.47)	(-4.41)	(-5.47)
GPD	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001***
	(-11.49)	(-9.01)	(-9.97)	(-8.75)	(-15.44)	(-16.38)
INF	0.0000	0.0000	0.0000	0.0000	-0.0000	0.0000
	(0.58)	(0.93)	(0.14)	(0.70)	(-0.23)	(0.49)
TXJ	0.0000	0.0000**	0.0000	0.0000*	0.0000	-0.0000
	(1.29)	(2.31)	(0.37)	(1.80)	(0.17)	(-1.34)
OM	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(-8.80)	(-8.63)	(-9.47)	(-8.92)	(-10.01)	(-9.09)
SMR	0.0007***	0.0007***	0.0007***	0.0007***	0.0006***	0.0006***
	(10.22)	(14.28)	(9.32)	(13.15)	(9.66)	(11.38)
Country _Mexico	-0.0002	-0.0003**	-0.0004**	-0.0003***	-0.0005***	-0.0005***
	(-1.12)	(-2.62)	(-2.38)	(-2.90)	(-5.05)	(-4.93)
Country _Chile	-0.0000	0.0002	-0.0002	0.0001	-0.0003***	-0.0003***
	(-0.24)	(1.29)	(-1.51)	(0.58)	(-2.96)	(-3.75)
Constant	0.0004	0.0015**	0.0021**	0.0019***	0.0025***	0.0014
	(0.22)	(2.13)	(2.26)	(2.78)	(2.81)	(1.55)
N	3740	3723	3740	3723	3740	3740
F	0.000	0.000	0.000	0.000	0.000	0.000
VIF	11.11	5.46	6.49	3.99	5.58	5.20
Wooldridge	0.000	0.000	0.000	0.000	0.000	0.000
Wald	0.000	0.000	0.000	0.000	0.000	0.000
AR(1)	0.000	0.000	0.000	0.000	0.000	0.000
AR(2)	0.162	0.001	0.106	0.000	0.000	0.000
Sargan	0.000	0.000	0.000	0.000	0.000	0.000

Note. * Significance at 10%. **5%. ***1%. Estimated coefficients according to the GMM. t statistic in parentheses.

5 DISCUSSION OF THE RESULTS

5.1 Descriptive Statistics and correlation matrix

It can be seen in Table 1 that the variables that represent the leverage measures had 3,904 observations, with the highest average among the measures being total leverage, which also had the highest standard deviation, while short-term leverage had the lowest average. Furthermore, it is noted that Brazilian companies have the highest leverage levels.

The volatility variable had 3,844 observations, with an average of approximately 0.00077 units. In addition, Brazil had the highest average volatility in the period, while Chile had the lowest average volatility. Brazil also had the highest levels of leverage in all measures analyzed. In addition, Brazil had the highest average growth rate of inflation and interest rates, with Chile standing out for having the highest average GDP growth rate.

Based on the results of the correlation matrix, as shown in Table 2, it is observed that the leverage measures showed a positive and significant correlation at the 5% level with the volatility variable. Thus, there is expected to be a positive relationship between leverage and the SRV of Latin American firms, thus indicating confirmation of the research hypothesis.

The crisis variable, one of the variables of interest in the study, also showed a positive correlation with the SRV. This relationship was statistically significant at the 5% level and indicates that in periods of crisis, assets tend to be more volatile.

5.2 Influences of Leverage on Volatility

It is observed that, in all the models in Table 3, leverage showed a positive relationship with the volatility of stock returns, thus confirming the study's hypothesis. This result has a confidence of 99% for the six leverage measures used in the study, and it can be inferred that, in Latin American companies whose managers decide to increase their leverage, the volatility of their assets tends to increase.

This relationship occurs because these firms are more likely to face financial difficulties and, thus, increase their bankruptcy costs due to the increase in their obligations concerning their assets or equity; this increases the company's market risk, according to Myers (1984) and Myers and Majluf (1984), which is reflected in the SRV, which can be considered a risk measure. This result corroborates the studies by Smith and Yamagata (2011) and Alaoui et al. (2017), indicating a positive relationship between these variables. This study shows that this relationship is confirmed in emerging Latin American countries.

The crisis variable also showed a positive relationship with stock volatility, and this relationship was statistically significant at the 1% level in the six analyzed models. This result occurs because periods of economic crisis are associated with a reduction in the level of activity of firms, with uncertainties about demand and the economy's future. In this way, uncertainties related to periods of crisis are positively reflected in the volatility of stock prices, evidencing the increased risk of assets in these periods, as well as the fear of shareholders that companies face financial difficulties, as pointed out by Alaoui et al. (2017) and Schwert (1989).

However, the interaction between the leverage and economic crisis variables showed a negative relationship with stock volatility. The relationship was statistically significant at the 1% level, except for model 5, which was statistically significant at the 10% level. This relationship is justified because, given the uncertainties related to periods of crisis, companies tend to reduce their degree of leverage due to the tendency to reduce investments made and the greater difficulty in obtaining credit, according to Campello et al. (2010) and Zeitun et al. (2017). Thus, in the context of economic crises, despite the tendency of managers to reduce the degree of leverage, asset volatility will tend to increase, regardless of the company's efforts to reduce leverage due to uncertainties related to periods of economic crisis.

Firm size (SIZE) showed a negative relationship with SRV in models 2, 3, 4 and 5, indicating that larger companies, based on their operating income, tend to present lower levels of volatility. This result was statistically significant at the 1% level for models 2, 3, and 4 and 5% for model 5. The relationship is justified, as larger companies tend to present less volatile results and greater stability in the market, as Chelley-Steeley and Steeley (2005) pointed out.

The ROE showed a negative relationship with the SRV, which showed statistical significance at the 1% level in the six analyzed models. This result occurs because companies that increase their net income concerning their equity have good growth prospects, transmitting greater security to shareholders and, therefore, reducing the SRV. This relationship differs from the results of Alaoui et al. (2017), who found no significant relationship between the variables, and this difference may be related to the target region of the analysis since Thampanya et al. (2020) also found evidence of a positive relationship between variables in emerging countries.

Concerning the macroeconomic control variables, it is observed that the GDP presented a negative relation with the SRV, being statistically significant at the 1% level for all the models in Table 3. The result indicates that when the GDP growth rate of Latin American countries increases, the SRV of companies in that region tends to decrease. This relationship is in line with the results found by Thampanya et al. (2020), who found that companies tend to show better results in periods of GDP growth due to increased economic activity, which increases shareholder confidence in the prospects of companies. However, the result differs from Alaoui et al. (2017), who found no statistical significance between the variables.

The TXJ variable showed a positive relationship with the SRV in models 2 and 4, with statistical significance of 5% and 10%, respectively. The connection is justified, as increases in the basic interest rate are related to increases in the costs of obtaining credit by companies

and an increase in the minimum remuneration required by shareholders, increasing the volatility of assets. This result aligns with that pointed out by Mittnik et al. (2015) and Thampanya et al. (2020).

Also, according to Table 3, OM has a negative relationship with SRV, with a statistical significance of 1%. Thus, countries with a greater money supply tend to lower their SRV; this can be justified, for example, as follows: in periods of greater volatility, there is a tendency for investors to transfer their resources to other markets considered safer (less volatile) and, with that, the volatility of the market in Latin countries Americans tends to increase. This relationship is under the results of research by Thampanya et al. (2020).

The SMR has a positive relationship with the SRV, with the result being significant at the 1% level. This result is in line with Lintner's (1965) and Sharpe's (1964) asset pricing models, which indicate that risk and return are directly proportional. to offset the additional risk, and thus, the volatility of these assets will also tend to be greater. This result does not confirm the study by Feng et al. (2017), who found no statistical significance for this relationship.

As for the dummy variables for the country, they indicated that the shares of Chile and Mexico tend to be less volatile than the shares of Brazil, confirming the result of the analysis of the parameters of the EGARCH model. Furthermore, the INF variable did not show a statistically significant relationship with the SRV of Latin American firms.

6 FINAL CONSIDERATIONS

This study aimed to analyze the relationship between leverage and volatility based on Latin American countries, and it was found that there is a positive relationship between the variables, as increases in debt levels increase the probability that firms face financial difficulties, as well as market risk. In addition, the results indicate that stock volatility tends to

be greater in periods of crisis, and in these periods, even if companies reduce their debt levels, volatility will tend to increase due to uncertainties related to negative periods. Also, both corporate and macroeconomic variables proved relevant to explain volatility.

This study contributes to the advancement of the theory by using the EGARCH model as a method for estimating volatility, which proves to be more efficient for its estimation because it considers the asymmetry of volatility, and the explained variable was related to six leverage measures. The moderating effect of the economic crisis on the relationship between leverage and volatility was also considered, with results controlled for firm and macroeconomic variables. Furthermore, the analyzed relationship was little explored in finance studies, making this scarcity even more evident in emerging countries.

The study is limited by the number of companies in the sample, which consists of a limitation of the EGARCH model for estimating volatility, which is the liquidity of the assets analyzed during the entire period. For future studies, comparing the results obtained from samples of emerging and developed countries is recommended. Also, it is recommended to use other methods for estimating volatility for comparison purposes, such as the PARCH model. In addition, it is recommended that future studies consider the influence of the sector of activity of firms based on a larger sample of companies.

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Volatilidade e Alavancagem: uma Análise das Empresas da América Latina

RESUMO

Objetivo: *Analisar a relação entre o nível de alavancagem e a volatilidade das ações da América Latina, no período de janeiro de 2005 a junho 2020.*

Método: *Utilizou-se uma regressão linear múltipla, sendo os coeficientes estimados pelo GMM e com os dados dispostos em painel. A volatilidade foi estimada pelo modelo EGARCH e utilizou-se seis medidas de alavancagem.*

Originalidade/Relevância: *O estudo analisa a relação entre volatilidade e alavancagem no contexto da América Latina e mostra que os períodos de crise podem afetar essa relação. Os resultados são relevantes para gestores, que podem ajustar estrategicamente o grau de alavancagem a fim de maximizar o valor da empresa para os acionistas, e também para os investidores, pois permite um melhor alinhamento entre o seu perfil de risco e o retorno almejado.*

Resultados: *Os resultados apontam que há uma relação positiva entre o grau de alavancagem da firma e a volatilidade dos ativos. Também se constatou que, em períodos de crise, mesmo que as empresas reduzam seus níveis alavancagem, a volatilidade tenderá a aumentar devido às incertezas relacionadas a esses períodos.*

Contribuições Teóricas/Metodológicas: *Na análise da relação entre alavancagem e volatilidade, também se verificou o efeito moderador dos períodos de crise e considerou-se a endogeneidade entre as variáveis por meio do GMM. Além disso, a volatilidade foi estimada por meio do modelo EGARCH que considera as assimetrias da volatilidade, sendo os resultados controlados por variáveis corporativas e macroeconômicas.*

Palavras-Chave: *Volatilidade, Alavancagem, Crise, EGARCH, GMM.*

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