THE DYNAMIC RELATION BETWEEN RETURNS, TRADING VOLUME AND VOLATILITY IN BRAZILIAN STOCK-LISTED AGRIBUSINESS COMPANIES

RELAÇÃO DINÂMICA ENTRE RETORNO, VOLUME DE NEGOCIAÇÕES E VOLATILIDADE DAS AÇÕES DAS EMPRESAS DE CAPITAL ABERTO DO AGRONEGÓCIO BRASILEIRO

Valéria Gama Fully Bressan
Doutora em Economia Aplicada
Bolsista de Desenvolvimento Tecnológico Industrial do CNPq.
Departamento de Economia Rural
Universidade Federal de Viçosa
valeria.fully@gmail.com

Aureliano Angel Bressam
Doutor em Economia Aplicada
Professor Adjunto da Faculdade de Ciências Econômicas
Universidade Federal de Minas Gerais
Pesquisador do CNPq.

João Eustáquio de Lima
PhD pela University of Florida
Professor Titular do Departamento de Economia Rural
Universidade Federal de Viçosa
Pesquisador do CNPq.

Marcelo José Braga
PhD pela University of Califórnia at Davis
Professor Adjunto do Departamento de Economia Rural
Universidade Federal de Viçosa
Pesquisador do CNPq.

ABSTRACT - In order to verify similarities and/or differences on the behavior of returns and volatility on traded stocks of Brazilian agribusiness companies, this study examines the existence of leverage effects and tests the hypothesis that trading volume is a useful proxy for information innovations, for a sample of 25 stock-listed Brazilian agribusiness companies. Using daily data from July/1999 to January/2007, two specifications of EGARCH models are tested, with and without trading volume as an explanatory variable. The results confirm the existence of leverage effects for almost all of the analyzed companies, and some influence of trading volume in the explanation of the volatility dynamics, but without any remarkable differences between companies and/or their related sub-sectors.

Keywords: Financial Returns, Trading Volume, Volatility, EGARCH, Agribusiness.

1 INTRODUCTION

The purpose of this paper is to examine the dynamic relation between stock returns, trading volume and volatility for 25 stock-listed Brazilian agribusiness-related companies. Previous studies, such as those conducted by Chen, Firth and Rui (2001) and Tabak and Guerra (2003), evaluated such relation in stock markets of several countries, such as the United States, Japan, U. Kingdom, France, Canada, Italy, Hong Kong and Brazil. In an alternative approach, this study intends to evaluate this relation for a specific economic sector, in order to identify some specific features that could be observed in Brazilian agribusiness companies.

Specifically, the purpose of this paper is to evaluate if returns are conditioned by the arrival of new information that affect trading volume. The 25 companies in the analyzed sample are characterized as those which have stocks traded in the Brazilian Stock Exchange (BOVESPA) until January 2007. These companies represent specific activities, such as fishery and agriculture, foods and beverages, paper and pulp, textiles, fertilizers, tobacco and industrial machinery, classified according to Economática's database.

The analysis is based on an EGARCH model that is estimated in order to verify the existing relations between returns, trading volume and conditional volatility. The results are analyzed in a comparative manner, intending to verify possible similarities and differences between sectors and companies.

The investigation about the relation between stock returns and trading volume is an important issue in financial research. Karpoff (1987) lists three main reasons for the importance of researches regarding this relation. First, the returns/trading volume relation provides important insights about the structure of financial markets. Second, its importance for event studies that use these relations to draw inferences about market efficiency. Third, that relation is a critical issue in the investigation of the empirical distribution of speculative prices.

The returns/trading volume relation is studied with different approaches among researchers. For instance, Granger and Morgenstern (1963) used the relation between stock indexes and aggregated transaction volume, while Crouch (1970) worked with the absolute variation of prices and trading volume. Westerfield (1977), Tauchen and Pitts (1983) and Rogalski (1978) analyzed the relation between price variations (returns) and trading volume. Epss and Epps (1976) examined the relation between the variance of returns and trading volume, while Harris (1986) and Clark (1973) investigated the relation between the square of price variations and trading volume.

Some recent results in the literature are of special interest to this study. Gallant, Rossi and Tauchen (1992), using daily data from the New York Stock Exchange between 1928 and 1987, investigated the returns/trading volume relation, with some interesting results: (i) positive correlation between conditional volatility and trading volume, (ii) large price movements are followed by high trading volume, (iii) the conditioning on trading volume reduces the leverage effect on volatility, and (iv) after conditioning on

lagged volume, there is a positive relation between risk and return.

Andersen (1996) developed an empirical model of trading volume and volatility from a microstructure framework in which informational asymmetries and lack of liquidity motivates the negotiation derived from the arrival of new information. Using a sequential information arrival hypothesis, the dynamic characteristics are driven by the information flow and modeled as an ARCH process. The results indicate that the model can be useful for the analysis of economic factors that are behind the observed volatility clusters.

Chordia and Swaminathan (2000) examined the interaction between trading volume and return predictability of daily returns. The results indicated that returns with high trading volume lead stock returns with low trading volume, a result that was explained by the authors as a tendency of high volume stocks to respond promptly to new information. Kuo, Hsu and Chiang (2004) applied the same model of Chordia and Swaminathan (2000) for the Taiwanese market, finding similar results along with some market inefficiencies.

Although these studies have some implications for causal relations between trading volume and stock returns, neither has analyzed a specific economic sector, in order to confirm or reject the results found in the literature. In this study, such empirical relations are examined for 25 stock-listed Brazilian agribusiness companies, in order to identify the existing relations between returns and trading volume.

2 THE DATA

This paper analyzes all the companies listed in BOVESPA wich are classified in one of three sub-sectors of Brazilian agribusiness, namely: *agricultural production, economic inputs and production factors and processing & distribution* sector.

The daily price and trading volume data of these stocks were extracted from Economatica® database from July/1994 to January/2007. Initially the sample was composed by 35 companies. However, those which have their register cancelled during that period were excluded from the sample, resulting in a final sample of 25 companies: Alpargatas, Ambev, Aracruz, Avipal, Buettner, Cacique, Cambuci, Coteminas, Fertibras, Fosfertil, Guararapes, Klabin, Minupar, Perdigão, Rasip Agro Pastoril, Sadia, Santista Têxtil, Souza Cruz, Suzano Papel, Teka, Vicunha Têxtil, Vigor, Votorantim C P, Weg and Yara Brasil.

The returns were calculated in the logarithmic form, resulting $Rt = \log(Pt/P_{t-1})$, where *Pt* is current price and P_{t-1} is the *1-period* lagged price. The volume is the product between the current price and the number of traded stocks on the specific class (common or preferred stocks). Volatility is defined as the square-root of the square of returns, according to the zero-mean hypothesis of expected returns, as described in Taylor (2005).

3 THE MODEL

Following Enders (2004), an important feature of stock prices is that “bad” news tends to have a higher effect on volatility

then "good" news of the same magnitude, a stylized fact known in the literature as "leverage effect".

Another special feature is that financial returns tend to exhibit fat tails in their distributions and for that reason GARCH-based models are widely applied in financial literature, once that these models can incorporate not only the leptokurtosis of squared returns, but also their lagged dependence. Among the existing models in the GARCH family, this study uses the EGARCH (Exponential Generalized Autoregressive Conditional Heteroscedasticity) following the previous applications of Hiemstra and Jones (1994), Silvapulle and Choi (1999) and Chen, Firth and Rui (2001).

The adequacy of the EGARCH model was exposed by Nelson (1991) which shown that it is better suited for daily data with persistence in volatility, presenting conditional lognormal variance in continuous time. As a consequence, as the time interval becomes shorter, the innovations distribution is a mixture of normal and lognormal distributions. In this sense, Hiemstra and Jones (1994) argue that the EGARCH model is better suited to verify causal relations between trading volume and stock returns. However, Alexander (2001) mentions that forecasting from EGARCH models is a difficult task, since an analytical form for the volatility term cannot be defined precisely.

Following Chen, Firth and Rui (2001), the present study uses an EGARCH (1, 1) specification, which defines a model for the estimation of the dynamics of returns volatility as:

Mean Equation:

$$R_t = a + bR_{t-1} + \varepsilon_t \qquad (1)$$

$$\varepsilon \mid I_{t-1} \sim N(0, h_t).$$

Variance Equation:

$$\ln(h_t) = \alpha_0 + \alpha_1\left(\frac{\varepsilon_{t-1}}{h_{t-1}^{0,5}}\right) + \lambda_1\left|\frac{\varepsilon_{t-1}}{h_{t-1}^{0,5}}\right| + \beta_1 \ln(h_{t-1}) \qquad (2)$$

Equation (2) defines the EGARCH model, which presents the following interesting features: (i) the equation for the conditional variance is in log-linear form and, as a consequence, the ht term that represents conditional variance can not be negative; (ii) instead of using ε_{t-1}^2, the EGARCH model uses the level of the standarized residual of ε_{t-1}(i.e.,$\varepsilon_{t-1}/(h_{t-1})^{0,5}$), allowing an easier interpretation of the size and persisitence of shocks, with the standardized value as a unit measure (ENDERS, 2004); (iii) the EGARCH model captures the leverage effect when α_1 is statistically different from zero (Morettin and Toloi, 2004) and, according to Brooks (2002), if the relation between volatility and return is

negative, then α_1 must be negative, indicating then the leverage effect.

The β_1 coefficient in the variance equation tends to be, according to Chen, Firth and Rui (2001) considerably higher than α_1, indicating that unexpected market movements induce to relatively small adjustments in the expected volatility. The persistence in the conditional variance process, which is measured by $\alpha_1 + \beta_1$, is high and in most cases close to unity, with higher values associated with a greater persistence in volatility.

In order to examine the hypothesis that the information flow to the market helps to explain the volatility of returns, a lagged volume term – denoted by V_{t-1} – is included in the variance equation as a proxy to information innovations, following Chen, Firth and Rui (2001). In this sense, the daily trading volume was used as a measure of the quantity of daily information that arrives to the market. This model is defined by the following equations:

Mean Equation:

$$R_t = a + bR_{t-1} + \varepsilon_t \qquad (3)$$

$$\varepsilon \mid I_{t-1} \sim N(0, h_t).$$

Variance Equation:

$$\ln(h_t) = \alpha_0 + \alpha_1 \left(\frac{\varepsilon_{t-1}}{h_{t-1}^{0,5}} \right) + \lambda_1 \left| \frac{\varepsilon_{t-1}}{h_{t-1}^{0,5}} \right| + \beta_1 \ln(h_{t-1}) + \chi_1 V_{t-1} \qquad (4)$$

The expected sign of the coefficient of the lagged volume, according to Chen, Firth and Rui (2001) is positive and, in the presence of volume with $\chi_1 > 0$, α_1 and β_1 tend to be statistically insignificant. Also, the persistence in variance measured by $\alpha_1 + \beta_1$ tends do become negligible if accounting for the uneven flow of information *(V)* explains the presence of EGARCH in the data.

Finally, according to Najand and Yung (1991) and Watanabe (2001), inferences in equation (4) can be made only if volume is exogenous and therefore lagged volume *(V_{t-1})* is included in the model specification.

4 EMPIRICAL RESULTS

In consonance with Chen, Firth and Rui (2001) the analyzed series presents time-variant volatility, a well-known fact in financial returns. As shown in Tables 1a to 1c, the Maximum Likelihood (ML) statistics are high for 18 of the 25 analyzed stocks. This result indicates that the EGARCH is an adequate model to describe the time dependence in daily returns. It is important to notice that the stocks with lower liquidity – Buettner, Cacique, Cambuci, Perdigão, Rasip, Vicunha and Vigor – don't show significant ML statistics. These stocks,

and also the stocks from Avipal and Sadia, were excluded of the analysis due to the absence of statistically significant ARCH effects.

Among the companies whose stocks presented ARCH effects – Alpargatas, Ambev, Aracruz, Coteminas, Fosfertil, Guararapes, Klabin, Minupar, Santinsta, Souza Cruz, Teka, Votorantim, Weg and Yara Brasil – the majority of the EGARCH estimates for Equation (2) were statistically significant, with an exception made for the results of Minupar and Suzano. The β coefficient was considerably higher then α, indicating that unexpected market movements induce to relatively small changes in expected volatility. The persistence in volatility, measured by $\alpha + \beta$, was close to unity, except for the results of Santista's stocks. The obtained results also indicate that current information is relevant to predict future volatility in the short run.

TABLE 1-A – ESTIMATION RESULTS FOR THE EGARCH MODELS OF BRAZILIAN AGRIBUSINESS COMPANIES

Company	Alpargatas	Ambev	Aracruz	*Avipal*	*Buettner*	*Cacique*	*Cambuci*	Coteminas
a	0,003	0,0009	0,0008	*0,00069*	*0,005*	*0,007*	*-0,007*	0,0004
	(6,976)*	(2,427)**	(2,129)**	*(1,297) ns*	*(0,657)ns*	*(3,973)**	*(-3,432)**	(0,987)ns
b	-0,055	0,066	0,008	*-0,131*	*-0,038*	*-0,159*	*0,042*	0,0358
	(-2,919)*	(3,600)*	(0,509)ns	*(-5,791)**	*(-0,57)ns*	*(-3,525)**	*(1,051)ns*	(1,945)***
α_0	-0,197	-0,858	-0,098	*-1,605027*	*-5,078*	*-0,779*	*0,005*	-0,537
	(-13,977)*	(-15,951)*	(-14,199)*	*(-13,86)**	*(-4,734)**	*(-4,813)**	*(0,469)ns*	(-13,993)*
λ_1	0,145	0,304	0,124	*0,3707*	*0,008*	*0,252*	*-0,025*	0,227
	(22,551)*	(21,948)*	(19,147)*	*(18,588)**	*(0,112)ns*	*(5,419)**	*(-2,353)***	(18,969)*
α_1	-0,025	-0,069	-0,039	*-0,0376*	*0,207*	*0,045*	*-0,087*	-0,048
	(-3,918)*	(-7,309)*	(-8,681)*	*(-2,596)**	*(3,519)**	*(1,763)****	*(-12,698)**	(-6,279)*
β_1	0,986	0,917	0,999	*0,8001*	*-0,187*	*0,892*	*0,995*	0,949
	(537,484)*	(151,799)*	(1289,937)*	*(50,452)**	*(-0,74)ns*	*(36,544)**	*(653,245)**	(204,691)*
L-Box (24)	17,072	29,691	35,663	*30,500*	*57,900*	*21,221*	*33,489*	30,515
For the mean	[0,806]	[0,158]	[0,045)	*[0,136]*	*[0,000]*	*[0,568]*	*[0,073]*	[0,135]
L-Box (24)	58,478	16,863	65,568	*23,349*	*18,130*	*14,497*	*30,586*	20,316
For the variance	[0,000]	[0,816]	[0,000]	*[0,441]*	*[0,750]*	*[0,912]*	*[0,133]*	[0,623]
ML	5044,939	7558,767	7029,881	*4790,669*	*262,1736*	*1016,369*	*435,2508*	6273,373
LM Test	7,256*	3,149***	40,369*	*2,128ns*	*0,003ns*	*0,928ns*	*0,794ns*	7,843*
$\alpha_1 + \beta_1$	0,961	0,848	0,96	*0,763*	*0,02*	*0,937*	*0,908*	0,901

ns = non-significant; ML = Maximum Likelihood; * 1% significance; ** 5% significance; *** 10% significance; ( ) z statistic; [ ] p-value.

Note: The information in italic was excluded from the analysis as a result of the non-rejection of the null hypothesis in the LM test.

Source: Estimation results.

The leverage effect was verified in the returns of Alpargatas, Ambev, Aracruz, Coteminas, Fosfertil, Guararapes, Klabin, Souza Cruz, Teka, Votorantim, Weg and Yara Brasil stocks, indicating that negative shocks generate higher volatility in the returns than positive shocks of same magnitude.

TABLE 1-B – ESTIMATION RESULTS FOR THE EGARCH MODELS OF BRAZILIAN AGRIBUSINESS COMPANIES

Company	Fosfertil	*Fertibras*	Guararapes	Klabin	Minupar	*Perdigão*	*Rasip*	*Sadia*
a	0,001	*0,002*	0,003	0,0012	-0,006	*0,004*	*0,0038*	*0,0007*
	(3,839)*	*(3,239)**	(4,954)*	(2,812)*	(-5,587)*	*(2,717)**	*(2,319)***	*(1,561)ns*
b	-0,011	*-0,114*	-0,219	-0,003	-0,255	*-0,059*	*-0,352*	*0,0619*
	(-0,627)ns	*(-4,821)**	(-9,269)*	(-0,184)ns	(-12,093)*	*(-1,371)ns*	*(-10,38)**	*(3,349)**
α_0	-0,187	*-0,232*	-0,389	-0,583	-0,239	*-0,139*	*-0,679*	*-0,466*
	(-12,495)*	*(-15,286)**	(-14,091)*	(-11,568)*	(-11,646)*	*(-8,798)**	*(-9,063)**	*(-9,651)**
λ_1	0,151	*0,230*	0,241	0,245	0,197	*-0,021*	*0,203*	*0,183*
	(19,577)*	*(22,869)**	(23,587)*	(19,624)*	(15,527)*	*(-1,147)ns*	*(9,377)**	*(11,444)**
α_1	-0,016	*-0,032*	-0,018	-0,045	-0,0072	*0,129*	*0,071*	*-0,048*
	(-3,549)*	*(-4,332)**	(-2,729)*	(-4,708)*	(-0,695)ns	*(9,735)**	*(3,098)**	*(-5,559)**
β_1	0,989	*0,989*	0,964	0,943	0,982	*0,977*	*0,894*	*0,9554*
	(586,138)*	*(456,319)**	(254,686)*	(149,081)*	(295,738)*	*(353,231)**	*(71,478)**	*(175,976)**
L-Box (24) For the mean	32,051 [0,099]	*37,795 [0,027]*	36,600 [0,036]	20,336 [0,622]	22,811 [0,472]	*16,787 [0,820]*	*36,235 [0,039]*	*44,429 [0,005]*
L-Box (24) For the variance	44,366 [0,005]	*21,117 [0,574]*	34,937 [0,053]	21,294 [0,563]	26,485 [0,279]	*22,151 [0,511]*	*20,484 [0,613]*	*16,222 [0,846]*
ML	7277,771	*3897,274*	3447,705	6550,307	2730,757	*617,0271*	*1078,986*	*7162,892*
LM Test	20,411*	*0,078ns*	3,922**	7,632*	16,128*	*0,368ns*	*0,189ns*	*2,333ns*
$\alpha_1 + \beta_1$	0,973	*0,957*	0,946	0,898	0,975	*1,106*	*0,965*	*0,907*

ns = non-significant; ML = Maximum Likelihood; * 1% significance; ** 5% significance; *** 10% significance; ( ) z statistic; [ ] p-value.

Note: The information in italic was excluded from the analysis as a result of the non-rejection of the null hypothesis in the LM test.

Source: Estimation results.

The results for Minupar and Suzano α_1 coefficients were statistically non-significant, indicating the absence of leverage effect for these companies, with that same coefficient presenting a positive result for the Santista's data.

In order to verify the estimated models, the Ljung-Box Q statistic was calculated for the standardized residuals and also to the square of those residuals, considering 24 lags. The obtained results indicate that the models estimated for Ambev, Coteminas, Fosfertil, Klabin, Minupar, Souza Cruz and Yara Brasil do not show any statistically significant serial correlation in the residuals (Tables 1-a to 1-c). Alternatively, the residuals of Aracruz, Alpargatas, Guararapes, Santista, Suzano, Teka, Votorantim and Weg presented serial correlation but, considering that the estimated models were not constructed to produce forecasts, that issue does not make invalid the analysis of the return/trading volume relation.

The verification of the hypothesis that the information flow in the market helps to explain the return volatility is tested by the estimation of equations (3) and (4), shown on Tables 2-a to 2-c. The estimated results for the α and β coefficients were statistically significant for almost all equations, exception made for the α coefficient of the models constructed for Minupar and Vigor returns.

Table 1-c – Estimation Results for the EGARCH models of Brazilian agribusiness companies

Company	Santista	Souza Cruz	Suzano	Teka	*Vicunha*	*Vigor*	Votorantim	Weg	Yara Brasil
a	0,002	0,001	0,0014	-0,002	*-0,003*	*0,004*	0,0006	0,002	-0,001
	(4,24)*	(2,615)*	(2,977)*	(-2,4)**	*(-2,453)***	*(2,73)**	(1,287)ns	(4,84)*	(-1,246)ns
b	-0,076	-0,013	-0,0003	-0,159	*-0,333*	*0,047*	0,0474	-0,072	-0,139
	(-12,23)*	(-0,75)ns	(-0,02)ns	(-7,96)*	*(-6,100)**	*(1,98)***	(2,934)*	(-3,92)*	(-7,567)*
α_0	-10,393	-0,535	-0,226	-0,294	*-0,815*	*-0,139*	-0,381	-0,104	-0,067
	(-380,9)*	(-10,73)*	(-10,29)*	(-9,09)*	*(-16,604)**	*(-11,80)**	(-12,198)*	(-9,69)*	(-12,765)*
λ_1	0,415	0,218	0,147	0,191	*0,682*	*0,151*	0,193	0,101	0,096
	(83,13)*	(15,43)*	(14,21)*	(15,16)*	*(22,889)**	*(16,27)**	(17,471)*	(17,34)*	(17,143)*
α_1	0,229	-0,017	-0,003	-0,016	*-0,159*	*-0,005*	-0,034	-0,019	-0,025
	(88,99)*	(-2,21)**	(-0,57)ns	(-1,9)**	*(-6,297)**	*(-0,71)ns*	(-4,782)*	(-3,58)*	(-5,977)*
β_1	-0,659	0,949	0,983	0,974	*0,929*	*0,993*	0,967	0,995	0,999
	(-134,5)*	(159,37)*	(391,91)*	(197,7)*	*(103,932)**	*(503,42)**	(254,599)*	(769,91)*	(1619,882)*
L-Box (24)	198,32	27,093	23,786	14,746	*27,246*	*44,670*	30,794	29,814	28,368
For the mean	[0,00]	[0,252]	[0,41]	[0,904]	*[0,246]*	*[0,004]*	[0,128]	[0,155]	[0,202]
L-Box (24)	143,35	33,050	41,834	48,030	*22,788*	*17,695*	100,33	57,022	23,730
For the variance	[0,00]	[0,080]	[0,009]	[0,00]	*[0,473]*	*[0,774]*	[0,000]	[0,00]	[0,419]
ML	2789,27	7168,47	6104,27	3756,12	*712,1791*	*1747,071*	6676,139	5295,16	2566,382
LM Test	3,963**	2,82***	10,32*	32,66*	*0,218ns*	*1,609ns*	65,414*	5,45**	9,604*
$\alpha_1 + \beta_1$	-0,432	0,932	0,981	0,958	*0,77*	*0,988*	0,933	0,976	0,974

ns = non-significant; ML = Maximum Likelihood; * 1% significance; ** 5% significance; *** 10% significance; ( ) z statistic; [ ] p-value.
Note: The information in italic was excluded from the analysis as a result of the non-rejection of the null hypothesis in the LM test.
Source: Estimation results.

The trading volume coefficient χ_1 was significant for the majority of the estimated models, with exceptions related to the results of Aracruz, Fosfertil, Klabin, Suzano, Weg, Teka and Yara Brasil which were non significant, and for the results of Minupar, which presented a negative sign.

The EGARCH effect remains significant when the lagged volume is included in the model. Nevertheless, the persistence in volatility is marginally lower then the results of equations (1) and (2) presented in Table 1, for the majority of the analyzed companies. Volume as a proxy for information innovations does not reduce the importance of α and β in the representation of the dynamics of volatility of the Brazilian agribusiness companies. These results are different from those expected in the specification of Chen, Firth and Rui (2001), generating a different interpretation of these estimates.

Such results suggest that volatility is better explained by its past behavior than by volume. The significance of coefficient χ_1 can be an indication that volume is an endogenous variable and that, for most of the analyzed series there exists a positive relation between the variance of returns ant past trading volume. Another possible

interpretation of this result is that volume is an inadequate proxy for information innovation.

It is important to notice that these results corroborate the view of Blume, Easley and O'Hara (1994), which argue that trading volume informs about the quality of the signs generated by information innovations, instead of representing the information signal itself. The authors also argue that a possible reason for the fact that information does not explain volatility is associated with the existence of noise trading in the market, as proposed by Black (1986).

Table 2-a – Estimation results of the EGARCH model with lagged trading volume

Company	Alpargatas	*Ambev*	Aracruz	*Avipal*	*Buettner*	*Cacique*	*Cambuci*	Coteminas
a	0,003	*0,0008*	0,0007	*-0,0008*	*0,006*	*0,007*	*-0,009*	0,0004
	(6,805)*	*(2,433)***	(2,122)**	*(-1,6)****	*(0,72)ns*	*(3,44)**	*(-3,995)**	(1,05)ns
b	-0,059	*0,064*	0,008	*-0,135*	*-0,027*	*-0,158*	*0,073*	0,032
	(-3,150)*	*(3,43)**	(0,504)ns	*(-5,699)**	*(-0,58)ns*	*(-3,62)**	*(1,472)ns*	(1,7)***
α_0	-0,171	*-0,892*	-0,098	*-2,215*	*-5,189*	*-0,702*	*-0,103*	-0,525
	(-13,468)*	*(-15,15)**	(-12,99)*	*(-15,32)**	*(-6,24)**	*(-4,77)**	*(-11,80)**	(-13,9)*
λ_1	0,133	*0,310*	0,124	*0,419*	*-0,014*	*0,205*	*0,079*	0,224
	(22,231)*	*(21,22)**	(17,89)*	*(18,186)**	*(-0,24)ns*	*(5,60)**	*(7,629)**	(18,81)*
α_1	-0,035	*-0,069*	-0,039	*-0,066*	*0,282*	*0,013*	*-0,165*	-0,047
	(-5,641)*	*(-7,27)**	(-8,635)*	*(-3,775)**	*(4,807)**	*(0,48)ns*	*(-13,70)**	(-6,11)*
β_1	0,989	*0,913*	0,999	*0,715*	*-0,211*	*0,901*	*0,985*	0,950
	(590,221)*	*(137,35)**	(1264,9)*	*(35,678)**	*(-1,09)ns*	*(39,30)**	*(696,34)**	(208,7)*
χ_1	1,58E-08	*1,04E-09*	9,44E-12	*3,65E-07*	*3,52E-06*	*3,06E-07*	*1,74E-09*	4,34E-09
	(5,771)*	*(2,60)**	(0,013)ns	*(7,520)**	*(2,88)*	*(3,35)**	*(0,019)ns*	(2,595)*
L-Box (24) For the mean	16,699 [0,824]	*29,878 [0,153]*	35,669 [0,045]	*33,454 [0,073]*	*52,931 [0,000]*	*23,454 [0,435]*	*24,663 [0,368]*	30,824 [0,127]
L-Box (24) For the variance	59,989 [0,000]	*17,246 [0,797]*	65,520 [0,000]	*29,608 [0,161]*	*16,260 [0,844]*	*16,386 [0,83]*	*17,553 [0,781]*	18,415 [0,735]
ML	5056,157	*7560,10*	7029,88	*4802,52*	*265,278*	*1021,35*	*415,34*	6274,23
LM Test	7,177*	*2,473ns*	40,308*	*0,439ns*	*0,010ns*	*0,439ns*	*0,02ns*	6,957*
$\alpha_1 + \beta_1$	0,954	*0,844*	0,96	*0,649*	*0,071*	*0,914*	*0,82*	0,903

ns = non-significant; ML = Maximum Likelihood; * 1% significance; ** 5% significance; *** 10% significance; ( ) z statistic;[ ] p-value.
Note: The information in italic were excluded from the analysis as a result of the non-rejection of the null hypothesis in the LM test.
Source: Estimation results.

5 CONCLUSIONS

The analysis of the ARCH effects in the returns of the Brazilian agribusiness stock-listed companies indicate that the stocks of Buettner, Cacique, Cambuci, Perdigão, Rasip, Vicunha and Vigor did not present any significant ARCH effects, a result that is possibly related to the low liquidity of those stocks in the analyzed period. On the other hand, the stocks of Alpargatas, Ambev, Aracruz, Coteminas, Fosfertil, Guararapes, Klabin, Minupar, Santinsta, Souza Cruz, Teka, Votorantim, Weg and Yara Brasil presented only ARCH effects, with persistence in volatility and leverage effects.

The results do not have any sector-specific issues, with a common feature that all the companies with high liquidity presented some similar results: shocks in the conditional variance take a long time to die out in the majority of the analyzed stocks, while the persistence in volatility, measured by $\alpha + \beta$, was close to unity, indicating that current information is relevant to predict future volatility in the short run for the analyzed sample. This is an important issue for risk managers and investors that take into account these assets in their porfolios.

Table 2-b – Estimation results of the EGARCH model with lagged trading volume

Company	Fosfertil	*Fertibras*	Guararapes	Klabin	Minupar	*Perdigão*	*Rasip*	*Sadia*
a	0,001	*0,002*	0,003	0,001	-0,006	*0,0002*	*0,004*	*0,0007*
	(3,831)*	*(3,298)**	(4,539)*	(2,799)*	(-5,57)*	*(0,21)ns*	*(2,2)***	*(1,6)****
b	-0,010	*-0,111*	-0,223	-0,004	-0,253	*-0,089*	*-0,332*	*0,061*
	(-0,612)ns	*(-4,692)**	(-9,105)*	(-0,19)ns	(-12,12)*	*(-2,23)***	*(-9,9)**	*(3,26)**
α_0	-0,189	*-0,230*	-0,447	-0,590	-0,199	*-0,104*	*-1,889*	*-0,617*
	(-12,493)*	*(-13,384)**	(-13,437)*	(-11,52)*	(-10,63)*	*(-8,64)**	*(-8,4)**	*(-9,58)**
λ_1	0,151	*0,227*	0,251	0,247	0,186	*-0,036*	*0,310*	*0,195*
	(19,170)*	*(19,766)**	(22,107)*	(19,55)*	(15,38)*	*(-2,30)***	*(7,5)**	*(11,0)**
α_1	-0,018	*-0,029*	-0,021	-0,046	-0,009	*0,128*	*0,188*	*-0,052*
	(-3,745)*	*(-3,906)**	(-2,919)*	(-4,73)*	(-0,87)ns	*(8,62)**	*(5,6)**	*(-5,18)**
β_1	0,989	*0,989*	0,956	0,943	0,987	*0,983*	*0,677*	*0,936*
	(582,968)*	*(438,152)**	(210,564)*	(146,45)*	(325,37)*	*(411,9)**	*(17,1)**	*(123,7)**
χ_1	2,96E-09	*-3,44E-08*	1,06E-07	1,75E-09	-1,63E-07	*1,18E-09*	*4E-06*	*6E-09*
	(1,029)ns	*(-1,93)****	(5,601)*	(0,63)ns	(-1,9)***	*(1,22)ns*	*(8,1)**	*(4,788)**
L-Box (24)	32,074	*36,823*	35,270	20,380	22,306	*15,206*	*41,952*	*44,450*
For the mean	[0,099]	*[0,034]*	[0,049]	[0,619]	[0,502]	*[0,887]*	*[0,01]*	*[0,005]*
L-Box (24)	44,042	*20,314*	30,953	21,043	30,805	*22,703*	*71,73*	*16,598*
For the variance	[0,005]	*[0,623]*	[0,124]	[0,578]	[0,128]	*[0,478]*	*[0,00]*	*[0,828]*
ML	7278,117	*3898,098*	3453,414	6550,46	2732,53	*614,26*	*1095,9*	*7172,9*
LM Test	20,305*	*0,063ns*	3,631***	7,301*	19,68*	*0,098ns*	*0,07ns*	*1,717ns*
$\alpha_1 + \beta_1$	0,971	*0,96*	0,935	0,897	0,978	*1,111*	*0,865*	*0,884*

ns = non-significant; ML = Maximum Likelihood; * 1% significance; ** 5% significance; *** 10% significance; ( ) z statistic;[ ] p-value.
Note: The information in italic were excluded from the analysis as a result of the non-rejection of the null hypothesis in the LM test.
Source: Estimation results.

Table 2-c – Estimation results of the EGARCH model with lagged trading volume

Company	Santista	*Souza Cruz*	Suzano	Teka	*Vicunha*	Vigor	Votorantim	Weg	Yara Brasil
a	0,002	*0,0009*	0,001	-0,002	*0,0006*	0,003	0,0003	0,002	-0,001
	(3,755)*	*(2,591)**	(2,9)*	(-2,3)**	*(0,81)ns*	(2,4)**	(0,561)ns	(4,8)*	(-1,205)ns
b	-0,046	*-0,017*	0,0004	-0,157	*-0,315*	0,051	0,0354	-0,072	-0,139
	(-7,414)*	*(-0,96)ns*	(0,02)ns	(-7,8)*	*(-5,97)**	(2,1)**	(1,72)***	(-3,93)*	(-7,484)*
α_0	-10,425	*-0,689*	-0,238	-0,279	*-0,879*	-0,107	-2,193	-0,103	-0,072
	(-358,9)*	*(-10,75)**	(-10,4)*	(-9,1)*	*(-15,3)**	(-11)*	(-14,53)*	(-9,1)*	(-12,319)*
λ_1	0,405	*0,244*	0,152	0,185	*0,649*	0,132	0,3842	0,101	0,099
	(77,0)*	*(15,75)**	(14,1)*	(14,8)*	*(17,8)**	(15,3)*	(18,97)*	(17,3)*	(17,159)*
α_1	0,214	*-0,021*	-0,004	-0,015	*-0,114*	-0,001	-0,029	-0,019	-0,023
	(64,8)*	*(-2,3)***	(-0,6)ns	(-1,8)***	*(-4,3)**	(-0,2)ns	(-2,04)**	(-3,57)*	(-5,214)*
β_1	-0,655	*0,932*	0,982	0,976	*0,916*	0,996	0,737	0,995	0,999
	(-135,7)*	*(119,5)**	(375,1)*	(209,1)*	*(88,1)**	(655)*	(36,23)*	(735,7)*	(1440,1)*
χ_1	3,1E-07	*1,06E-08*	1,42E-09	-3,5E-08	*-1E-06*	1E-07	2,30E-08	-7E-10	-2,02E-08
	(6,45)*	*(4,385)**	(1,38)ns	(-0,6)ns	*(-4,5)**	(8,8)*	(6,84)*	(-0,4)ns	(-1,363)ns
L-Box (24)	205,95	*27,430*	24,046	14,839	*26,316*	51,743	34,522	29,595	28,542
For the mean	[0,000]	*[0,238]*	[0,401]	[0,900]	*[0,286]*	[0,001]	[0,058]	[0,161]	[0,196]
L-Box (24)	143,59	*33,309*	41,250	50,627	*26,077*	30,392	79,110	57,762	23,130
For the variance	[0,000]	*[0,076]*	[0,011]	[0,001]	*[0,297]*	[0,138]	[0,000}	[0,000]	[0,453]
ML	2786,3	*7172,1*	6105,1	3756,2	*717,6*	1753,7	6675,64	5295,2	2566,5
LM Test	3,5***	*1,703ns*	10,031*	34,96*	*0,14ns*	6,13**	4,208**	5,413**	9,253**
$\alpha_1 + \beta_1$	-0,441	*0,911*	0,978	0,961	*0,802*	0,995	0,708	0,936	0,976

ns = non-significant; ML = Maximum Likelihood; * 1% significance; ** 5% significance; *** 10% significance; ( ) z statistic; [ ] p-value.

Note: The information in italic were excluded from the analysis as a result of the non-rejection of the null hypothesis in the LM test.

Source: Estimation results.

Another important result is that the estimated trading volume coefficient χ_1 was significant for the majority of the estimated models, is a variable that should be taken into account in an investment and risk management environment. Also, it is important to notice that volume did not reduce the importance of α and β in the representation of the volatility dynamics for Brazilian agribusiness companies, as expected. Indeed, this result raises some interesting research questions: does it indicate that volatility is better explained by its past behavior than by volume? The significance observed for the χ_1 coefficient can be an indication that volume is an endogenous variable? Is volume an suitable proxy for information innovation?

In order to answer these questions, some important research issues related to the results of this study are: the investigation of a dynamic relationship between volatility and volume using some alternative approaches, such as Markov-switching models, non-linear Granger Causality tests and Vector Autoregressions that consider liquidity as a relevant variable in the relation between returns and trading volume. Also, alternative estimation techniques based on the use of instrumental variables, in order to capture in an efficient manner

the arrival of new information to the market using alternative liquidity measures as instruments, can be useful.

Finally, the hypothesis that trading volume is a good proxy for information innovations was not verified for the analyzed sample, since the EGARCH effects were still statistically significant. Although these results can be due to the existence of short-term market inefficiencies or noise trading, they are restricted to the sample and the period considered in this study.

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