*Artigo de Pesquisa* *DOI: https://dx.doi.org/10.1590/1980-53575225rrga*

# Impact of Merger Announcements on the Stock Returns of Brazilian Acquiring Firms

**Ricardo Rezende Gomes Avelino**[1]

## Abstract

This paper assesses the impact of merger announcements on the market value of Brazilian acquiring firms based on 31 transactions that took place from 2004 to 2019 and in which the market value of the target was at least 10% of the market value of the acquirer. The estimates from the BEKK model, which extends the market model to incorporate time-varying betas and volatility clustering, suggest that abnormal returns to acquirers' stockholders over a 15-day window around the merger announcement are statistically and economically significant, amounting to 5.3584%. Financial and accounting indicators of acquirers prior to and after the merger do not rule out the possibility that these short-run returns reflect misassessment of market participants of the value created by mergers.

## Keywords

Merger announcement; Event study; Abnormal returns; BEKK model.

## Resumo

Este artigo avalia o impacto do anúncio de incorporações no valor de mercado de empresas brasileiras adquirentes com base em 31 transações que ocorreram entre 2004 e 2019 e nas quais o valor de mercado da companhia adquirida era pelo menos 10% do valor de mercado da empresa adquirente. As estimativas do modelo BEKK, que estende o modelo de mercado para incorporar betas com variação temporal e clusters de volatilidade, sugerem que os retornos anormais auferidos pelos acionistas das adquirentes em uma janela de 15 dias em torno do anúncio da fusão são estatística e economicamente significativos, no valor de 5.3584%. Indicadores financeiros e contábeis dos adquirentes antes e depois da fusão não eliminam a possibilidade de que esses retornos de curto prazo reflitam uma avaliação errônea dos participantes do mercado do valor criado pelas fusões.

## Palavras-chave

Anúncio de incorporação; Estudo de evento; Retornos anormais; Modelo BEKK.

## JEL Classification

C58; G14; G34.

---

[1] Professor - Faculdade de Economia, Administração, Contabilidade e Atuária - USP
Endereço: Av. Prof. Luciano Gualberto, 908 – Cidade Universitária - São Paulo - SP – Brasil
CEP: 05508-010 – E-mail: avelino@usp.br – ORCID: https://orcid.org/0000-0002-1343-8891
Recebido: 06/09/2021. Aceito: 06/01/2022.
Editor Responsável: Rodrigo De Losso da Silveira Bueno

## 1. Introduction

Numerous studies in the literature have attempted to measure the impact of the merger announcement on the stock returns of merging firms. See, *inter alia*, Mandelker (1974), Asquith (1983) and Malatesta (1983). These studies usually rely on some version of the market model to predict the returns that would be observed in the absence of the event and, hence, to construct the abnormal and cumulative abnormal returns. These statistics are then compared with the critical values of known distributions derived under the assumption of i.i.d. normal errors in the market model. Yet there is evidence that the distribution of daily returns exhibits fat tails, of volatility clustering and that beta is time-varying (See, for example, Bollerslev 1997 and Lettau and Ludvigson 2001). Some researchers investigating alternative questions address either the problem of non-normality and dependence of the errors by extending the market model to incorporate GARCH errors (Corhay and Tourani Rad 1996) or the issue of a time-varying beta through the employment of only part of the sample in the estimation window (MacKinlay 1997). An exception is de Jong, Kemna and Kloek (1992), who propose a state space model with GARCH-*t* errors and time-varying beta. However, the applicability of their model is restricted to periodic events such as the option-expiration and weekend effects that they analyze.

This paper uses a bivariate asymmetric BEKK model with Student-*t* errors, which builds on previous work of Engle and Kroner (1995) and Kroner and Ng (1998), to assess the impact of merger announcements on the market value of Brazilian acquiring firms over a 15-day window around the announcement date (henceforth referred to as the event window). The BEKK model assumes that the unconditional expectation of daily returns is constant and that the covariance matrix of the innovations is time-varying. These assumptions allow the derivation of the distribution of the acquiring firm returns conditional on the market returns, which can be interpreted as the conditional expectation in a regression of the acquirers' return on the market return. The slope of this regression, which is the analog to the beta in the market model, is a function of the elements in the covariance matrix and, hence, time-varying.

The estimates of the parameters of the covariance matrix obtained from an estimation window, along with knowledge of the distribution of the errors and of the observed values of the market return over the event window, enable us to simulate the returns of acquirers over the event window in the absence of the event. These simulated returns are used to construct a large number of simulated samples of the average cumulative abnormal daily returns of acquirers, which are compared with their observed values, yielding valid $p$ values for inference.

Based on 31 transactions that took place from 2004 to 2019 and in which the market value of the target was at least 10% of the market value of the acquirer, I estimate statistically and economically significant abnormal returns to acquirers' stockholders over a 15-day window around the merger announcement, which amount to 5.3584%. The results also provide evidence that market participants anticipate the events. Most of this abnormal return is concentrated on the days prior to and at the date of the announcement. By the end of $t=0$, the average cumulative abnormal returns reach 4.2248%, which represents 78.84% of the overall effect of 5.3584% over the entire 15-day window.

The Kolmogorov-Smirnov test for equality of the distribution of the standardized residuals of the asymmetric BEKK model with Student-$t$ errors and the Student-$t$ distribution does not show any evidence of misspecification. In addition, the ARCH-LM statistics do not provide evidence of lingering ARCH effects in the squared residuals. We conclude, therefore, that the model provides an adequate description of the dynamics of returns.

On the other hand, the likelihood ratio statistics to discriminate between the symmetric and asymmetric BEKK models with Student-$t$ errors provide strong evidence against the more restricted model, reinforcing the need to incorporate asymmetric effects of the innovations on the conditional covariance matrix. For six of the 31 bivariate regressions, there is also evidence of fat-tailed errors, as indicated by the observed values of the Schennach-Wilhelm statistic that compare the non-nested asymmetric BEKK models with normal and Student-$t$ errors.

The positive effect of 5.3584% documented in this paper is *a priori* consistent with the synergy hypothesis, which posits that mergers are motivated by the additional value created by the combined company that is not achievable by the firms operating independently, and with the "chain letter" hypothesis, which argues that mergers are driven by differences in price earnings (P/E) ratio between the acquirer and the target that may lead to a temporary overvaluation of the acquiring firm contemporary to the merger announcement. However, an analysis of financial and accounting indicators of acquirers prior to and after the merger does not rule out the possibility that this positive effect results from the misassessment of market participants of the value created by mergers.

It is worth noting that the positive effect documented in this paper contrasts with most of the international evidence summarized, for instance, in Jensen and Ruback (1983), which suggests that mergers in the U.S. are zero net present value investments for acquiring firms. The majority of these studies, however, does not control for the relative size of the target. An exception is the work of Asquith, Bruner and Mullins (1983), which reports the results for a subsample constructed using the same threshold of 10% employed in this paper. They find a statistically significant average abnormal return for bidders of 4.1% over a 21-day horizon, which is comparable in magnitude to the value of 5.3584% reported in this paper.

The evidence regarding the impact of merger announcements on the stock returns of Brazilian acquiring firms is scarce. Camargos and Barbosa (2006) previously estimated a simple market model based on a sample of 55 transactions that occurred between July 1994 and July 2002. The authors report an average cumulative abnormal return of 8.76% over a 41-day window around the announcement date.

All of these estimates in the cited literature, however, are plagued by the problems of non-normality of the errors, volatility clustering and time-varying beta previously highlighted, which casts doubt on the significance of the reported results.

The remainder of this paper is structured as follows. Section 2 reviews some hypotheses often invoked in the literature to explain the occurrence of mergers. Section 3 describes the data set used in this study. Section 4 presents the bivariate asymmetric BEKK model with Student-*t* errors applied to model the joint dynamics of the acquiring firm and the market daily returns. Section 5 proposes a Markov Chain Monte Carlo procedure to assess the statistical significance of the impact of the announcement of acquisitions on the stock returns of acquirers. Section 6 presents the empirical results. Finally, Section 7 concludes.

## 2. How Mergers Could Affect the Stock Returns of Acquiring Firms

There is no consensus in the theoretical literature on how mergers impact stock returns of acquiring firms. One strand of the literature focuses on the gains that stem from synergies. Synergies can be defined as the additional value of the opportunities created by the union of two firms that would otherwise not be available to these firms operating as separating entities. The synergies can be operational or financial.

Operational synergies, as emphasized by Damodaran (2005), can arise from several sources such as: (i) economies of scale, which reduce costs; (ii) increased market power, which raises profit margins and sales; (iii) a more complete control of the chain of production; and (iv) the gains that result from exploiting the strengths in different areas originally possessed by the merging firms.

Financial synergies, according to Damodaran (2005), may result, for example, from: (i) diversification, which reduces risk in case one of the two firms involved in a merger is a privately held owned or closely held publicly traded company; (ii) cash slack, when a firm with significant excess cash and few good reinvestment opportunities mergers with another firm in the reverse situation; (iii) tax benefits, when one of the companies has tax credits resulting from accumulated losses that have no prospect of being used; and (iv) increased debt capacity, which refers to the ability to acquire more debt from lending institutions through decreased gearing (leverage), which is usually thought to be a cheaper source of finance.

In either case, we expect stock prices to rise in response to merger announcements to reflect the additional value acquiring firms may obtain from the synergies.

Another strand of the literature highlights the role played by the so called "chain letter" effect, whereby there is an automatic and instantaneous increase in earnings per share of the acquiring firm whenever its P/E ratio is greater than that of the acquired firm. This occurs even when company A merges with an inferior company B and nothing really changed in the company and or in the economy.

This line of reasoning argues that, if company B has a lower P/E ratio than company A, this often results from a worse assessment of the future prospects of company B and of its growth rate. If this is the case and one assumes, in addition, as Lintner (1971) does, that expectations of the future usually reflect the recent past experience and that many investors base their investment decisions on P/E ratios, then the announcement of a merger should lead to a contemporaneous increase in the stock prices of the acquiring firm.

But with no abnormal internal growth in earnings of the combined firm, stock prices will eventually fall as growth expectations collapse. Thus, in contrast to the previous hypothesis of synergies, stocks of acquiring firms are expected to drop over time after the merger announcement.

A third explanation relies on the agency problem faced by publicly traded companies, in which managers do not necessarily act in the best interests of stockholders, and it is known in the literature as the growth-maximization hypothesis (Mueller 1969). It claims that managers place more weight on the growth of the firm than what would be desirable from the perspective of shareholders because the compensation managers receive and the prestige and power they derive from their occupations are typically tied to the size and growth of the firm and not to its profitability.

As a result, in the evaluation of the present value of investment opportunities, a company uses a lower discount rate in comparison with that which would be appropriate from the viewpoint of a stockholder welfare maximizer. In other words, the external growth achieved by a firm through merging with another company can destroy value to its shareholders. If market participants are aware of the utility function of the growth-oriented management, a merger announcement may trigger a contemporaneous decline in stock price.

A fourth reason usually invoked in the literature to explain the occurrence of merger acquisitions is Hubris hypothesis, proposed by Roll (1986). It asserts that managers of acquiring firms suffer from hubris, excessive pride and arrogance, which may lead them to overestimate their ability to add value to the combined company and, as a consequence, to pay premiums for illusory potential synergies or simply pay too much for mergers that result in positive net wealth gains.

The key elements underlying this hypothesis, therefore, are positive errors in valuation. As stressed by Roll (1986), if the bid is unanticipated and if it conveys no information about the bidder other than that it is seeking a combination with a particular target, we should expect a drop in the price of the acquiring firm on the announcement of the bid.

## 3. Description of the Data

The starting point for the construction of the dataset used in this study is a sample of 49 mergers and acquisitions between November 2004 and June 2019 in which both the acquirer and the target were listed in B3. I selected from this initial sample only those transactions in which the market value of the target at the end of the quarter prior to the announcement date was at least 10% of the market value of the acquiring firm. The choice of this threshold offers a compromise between the retainment of relevant transactions whose announcements presumably have an impact on the market value of acquirers and the availability of a non-negligible sample that allows us to estimate this effect with some precision.

Table 1 lists the final sample of 31 mergers and acquisitions analyzed in this paper, in conjunction with the announcement date and the market values of the firms at the end of the quarter prior to the announcement[1]. We see that there is a huge variation in the market values of the acquirers and of the targets, which range, respectively, from R$ 1.186 billion to R$ 93.830 billion and from R$ 436 million to R$ 31.604 billion. The acquirers' mean market value equals R$ 11.932 billion and is just over twice as large as that of R$ 5.314 billion for the targets.

---

[1] This final sample also excludes the merger between BM&F and Bovespa due to the small number of stock quotes prior to the announcement date, which does not allow us to estimate the parameters of the BEKK models with precision.

**Table 1 – Dates of Announcement of the Acquisitions and Market Values of the Acquirer and of the Target in the Quarter Prior to the Announcement**

| Companies | Announcement Date | Market Value (R$ billions) | |
|---|---|---|---|
| | | Acquirer | Target |
| Suzano Bahia Sul/Ripasa | 11/10/2004 | 3.366 | 1.357 |
| VCP/Ripasa | 11/10/2004 | 7.543 | 1.357 |
| Suzano Petroquímica/Polipropileno | 6/20/2005 | 1.186 | 977 |
| Net/Vivax | 10/11/2006 | 5.021 | 1.314 |
| Braskem/Copesul | 3/19/2007 | 5.089 | 5.723 |
| Unipar/Petroquímica União | 6/25/2007 | 1.590 | 1.084 |
| Vivo/Telemig | 8/2/2007 | 16.868 | 2.515 |
| Perdigão/Eleva | 10/31/2007 | 6.619 | 1.232 |
| Oi/Brasil Telecom | 4/25/2008 | 15.731 | 11.940 |
| Metalúrgica Gerdau/Aços Villares | 5/21/2008 | 13.381 | 2.865 |
| Cyrela/Agra | 6/23/2008 | 8.180 | 1.280 |
| Totvs/Datasul | 7/22/2008 | 1.398 | 658 |
| Gafisa/Tenda | 9/1/2008 | 3.581 | 1.795 |
| Brascan/Company | 9/10/2008 | 1.579 | 853 |
| VCP/Aracruz | 9/15/2008 | 8.681 | 14.430 |
| Itaú/Unibanco | 11/3/2008 | 93.830 | 31.604 |
| Perdigão/Sadia | 5/18/2009 | 5.938 | 2.522 |
| Pão de Açúcar/Ponto Frio | 6/8/2009 | 7.289 | 799 |
| Duratex/Satipel | 6/22/2009 | 1.777 | 436 |
| Amil/Medial | 11/19/2009 | 3.466 | 757 |
| Braskem/Quattor | 1/22/2010 | 12.299 | 1.746 |
| PDG/Agre | 5/3/2010 | 5.800 | 2.019 |
| Cemig/Light | 10/7/2010 | 16.532 | 4.405 |
| Drogasil/Raia | 8/2/2011 | 2.000 | 1.612 |
| Cosan/Comgás | 5/3/2012 | 13.730 | 5.118 |
| Kroton/Anhanguera | 4/22/2013 | 6.954 | 4.750 |
| B3/Cetip | 4/8/2016 | 27.475 | 10.434 |
| Kroton/Estácio | 7/8/2016 | 22.010 | 5.218 |
| Suzano/Fibria | 3/15/2018 | 20.409 | 26.470 |
| Kroton/Somos Educação | 4/23/2018 | 22.296 | 3.897 |
| Aliansce/Sonae Sierra | 6/6/2019 | 4.047 | 2.193 |
| All | | 11.932 | 5.314 |

This table lists the dates of announcement of the mergers over 2004-2019 in the subsample used in this study and presents the market values of the acquirer and of the target at the end of the quarter prior to the announcement, in billions of reais, with no adjustment for inflation. Market values were collected from Economatica.

Figure 1 depicts the evolution of the cumulative average daily return of acquirers over the 21-day interval centered at the announcement date. The cumulative average daily return sharply increases from day $t$=-7 to $t$=0, varying from -0.3762% to 4.3453% over this seven-day interval, and jumps to 4.7483% at the end of day $t$=7. We also observe that, in the days before day $t$=-7 and after $t$=7, the cumulative average daily return exhibits a slight/moderate decline. On the other hand, the average cumulative daily return of the index, over this same 21-day interval, oscillates between -0.9598 and 0.4803, showing no upward or downward trend, as expected. These figures suggest, therefore, that, if the goal is to uncover the impact of merger announcements on the market value of acquirers, we should focus primarily on the 15-day interval centered on the announcement date.

In the next section, I propose an asymmetric bivariate BEEK model with Student $t$-errors to model the dynamics of returns of acquiring firms and of the market. This model enables us to compare these average daily returns of acquirers with the corresponding returns that would be expected in the absence of the announcement of the transaction.

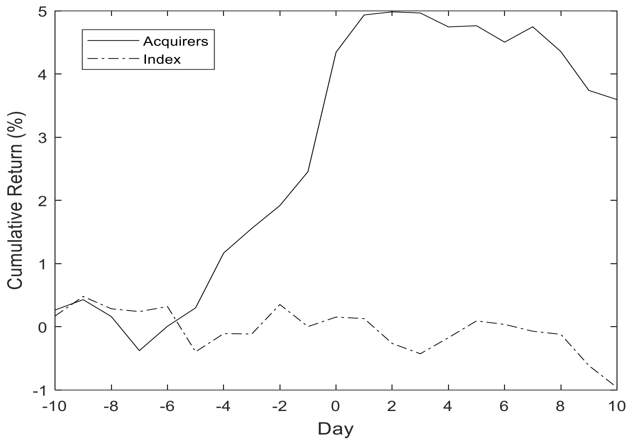

**Figure 1 - Average Cumulative Compounded Daily Returns for Acquirers and for the Ibovespa over the 21-Day Event Window Centered on the Merger Announcement**

This figure exhibits the evolution of cumulative average daily returns of 31 acquiring firms in 2004-2019 and of the Ibovespa cumulative average daily return over a 21-day window around the merger announcement. The cumulative return on the i-th acquiring company and the corresponding cumulative return on the Ibovespa between days -10 and $\tau_2$ are calculated, respectively, as $\sum_{t=-10}^{\tau_2} r_{it}$ and as $\sum_{t=-10}^{\tau_2} r_{mt}^{(i)}$, where $r_{it}$ and $r_{mt}^{(i)}$ denote the corresponding continuously compounded daily return of the i-th acquirer and of the benchmark at time t, as defined in Section 4. The cumulative average daily returns on acquirers and on the Ibovespa depicted in the figure are simple arithmetic averages of these individual cumulative returns over i.

## 4. Bivariate Asymmetric BEKK Model with Student-*t* Errors

First, let us define some notation to facilitate the measurement and analysis of abnormal returns. Let $P_{it}$ denote the price of security $i$ at day $t$ and define $r_{it}$ as the continuously compounded daily return of security $i$ at time $t$, that is,

$$r_{it} = 100(lnP_{it} - lnP_{it-1})$$

In addition, let $r_{mt}$ be the market return at time $t$, defined analogously to $r_{it}$. We assume that the evolution of $r_t=[r_{it},r_{mt}]'$ can be described by the following equations:

$$r_t = \mu + \varepsilon_t, \qquad \varepsilon_t = H_t^{1/2}\xi_t \tag{1}$$

$$\xi_t = \zeta_t\sqrt{\frac{v-2}{v}}, \qquad \zeta_t|\Im_{t-1}\sim N(0,I_2) \qquad v \sim \chi^2(v) \tag{2}$$

$$H_t = CC' + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B + G'\eta_{t-1}\eta'_{t-1}G \tag{3}$$

where $\mu$, $\varepsilon_t, \xi_t$ and $\eta_t$ are 2x1 vectors, $\eta_t = I(\varepsilon_t < 0)$, $\Im_t$ denotes the information set at time $t$, A, B and G are 2-dimensional square matrices, C is a 2-dimensional lower triangular matrix and $I_2$ is the identity matrix of order 2.

This is the BEKK model with leverage effects and Student-*t* errors, which is an extension of the asymmetric BEKK model with normal errors of Kroner and Ng (1998). Equation (1) says that the unconditional expectation of $r_t$ is constant over time, whereas, according to equations (2) and (3), the conditional variance of $\varepsilon_t$ is time-varying and given by $H_t$. The dynamics of the conditional variance ensures that $H_t$ is positive definite under weak conditions[2]. The model is covariance stationary if all eigenvalues of $(A\otimes A) + (B\otimes B) + (1/2)(G\otimes G)$ lie inside the unit circle.

---

[2] A sufficient condition for positivity is that at least one of the matrices C or B be of full rank and that the matrix $H_0$ be positive definite. See, for example, Engle and Kroner (1995).

The asymmetric BEKK model with Student-*t* errors provides a parsimonious representation compared to an unrestricted vec parameterization with leverage effects. In the bivariate case above, for instance, there are 15 unknown parameters in the equation describing the evolution of $H_t$, compared to 30 parameters in the unrestricted vec representation.

In the sequel, the model is estimated by maximum likelihood. Let $L_t$ be the log likelihood of observation *t* and L be the joint log likelihood. The conditional log likelihood function for a sample of *T* observations can be expressed as

$$L = \sum_{t=1}^{T} L_t$$

where $L_t$ is the logarithm of the joint density of $r_{it}$ and $r_{mt}$, which is given by

$$f\left(r_t \middle| \Im_{t-1}\right) = \frac{1}{\pi(v-2)} \frac{\Gamma\left(\frac{v+2}{2}\right)}{\Gamma\left(\frac{v}{2}\right)} |H_t|^{-1/2} \left[1 + \frac{1}{v-2} \varepsilon_t' H_t^{-1} \varepsilon_t\right]^{-\frac{v+2}{2}} \tag{4}$$

where Γ(.) stands for the gamma function.

We can initialize the recursion, for example, equating $H_0$ to the sample covariance matrix of the errors, that is,

$$H_0 = \sum_{t=1}^{T} \varepsilon_t' \, \varepsilon_t'$$

Collect the unknown parameters in the vector θ, denote by $\theta_0$ the true value of the parameters and assume that $L_t$ is continuously differentiable at $\theta_0$. Under the regularity conditions in Comte and Lieberman (2003), the maximum likelihood estimator is consistent and its asymptotic distribution is given by

$$\sqrt{T}\left(\hat{\theta} - \theta_0\right) \overset{d}{\rightarrow} N(0, J^{-1} \Omega J^{-1})$$

or, equivalently, if the model is correctly specified, by

$$\sqrt{T}\left(\hat{\theta}-\theta_0\right)\overset{d}{\to}N(0,J^{-1})$$

where Ω denotes the outer product of the score and J is the negative of the expected value of the Hessian.

The asymmetric BEKK model with Student-*t* errors is also sufficiently flexible to accommodate time-varying betas. To see this, note that, from the results in Ding (2016), it follows that the distribution of $r_{it}$, conditional on $r_{mt}$ and $\mathfrak{I}_{t-1}$, can be expressed as

$$r_{it}|r_{mt},\mathfrak{I}_{t-1}\sim t\left(\mu_{1|2,t},\Sigma_{1|2,t},v\right) \quad (5)$$

where $t\left(\mu_{1|2,t},\Sigma_{1|2,t},v\right)$ denotes a univariate Student-*t* distribution with location and scale parameters $\mu_{1|2,t}$ and $\Sigma_{1|2,t}$ and $v$ degrees of freedom, for

$$\mu_{1|2,t}=\mu_1+\mathrm{H}_{12,t}H_{22,t}^{-1}\left(\mathrm{r}_{mt}-\mu_2\right) \quad (6)$$

and

$$\Sigma_{1|2,t}=\frac{(v-2)+\varepsilon_{2t}^{'}H_{22,t}^{-1}\varepsilon_{2t}}{v+1}\left(\mathrm{H}_{11,t}-\mathrm{H}_{12,t}H_{22,t}^{-1}\mathrm{H}_{21,t}\right) \quad (7)$$

The conditional mean $\mu_{1|2,t}$ can be interpreted as the result of a regression of $r_{it}$ on $r_{mt}$. Thus,

$$\beta_t=H_{22,t}^{-1}H_{21,t}$$

## 5. Assessing the Impact of the Announcement of Acquisitions on Acquirers' Stock Returns Through Cumulative Average Abnormal Returns

Equipped with consistent estimates of $\theta_0$ obtained from a sample of size *T*, we can compute the abnormal return for security *i* at any future date τ as the difference between the actual return and the return predicted using equation (6), that is,

$$\widehat{\mathrm{ar}}_{i\tau}=\mathrm{r}_{i\tau}-\hat{\mu}_1-\widehat{H}_{12,\tau}\widehat{H}_{22,\tau}^{-1}\left(r_{m\tau}-\hat{\mu}_2\right) \quad (8)$$

Note that $\widehat{H}_\tau$ can be easily constructed using the recursion in equation (3), given the value of $\widehat{H}_T$, which is a byproduct of the maximum likelihood estimator, and the realizations of $\mathrm{r}_{i\tau'}$ and $\mathrm{r}_{m\tau'}$ for $T \leq \tau' < \tau$.

In general, we are primarily interested in the assessment of the impact of the event over a window of several days. In this case, the individual abnormal returns for firm $i$ must be aggregated through time. Define the cumulative abnormal return for security $i$ from $\tau_1$ to $\tau_2$ as the sum of the individual abnormal returns over this interval, namely,

$$\widehat{\mathrm{car}}_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} \widehat{\mathrm{ar}}_{i\tau} \tag{9}$$

In order to draw overall conclusions, we have to further aggregate the cumulative abnormal return across the $N$ securities, such as in (10):

$$\overline{\mathrm{car}}(\tau_1, \tau_2) = \frac{1}{N} \sum_{i=1}^{N} \widehat{\mathrm{car}}_i(\tau_1, \tau_2) \tag{10}$$

It remains to calculate the $p$ value associated with the null hypothesis that the statistic above equals zero. To do so, I augment the parameter space and treat the counterfactual acquirers' returns over the event window under the assumption of no merger as latent variables. Then, we can sample the unobservable acquirers' returns in the bivariate BEKK models, one at a time, conditional on the other unobservable acquirers' returns, on the estimated parameters and on the market returns over the event window, employing a Markov Chain Monte Carlo procedure[3].

Write the joint density of $\mathrm{r}_{\tau_1}, \ldots, \mathrm{r}_{\tau_2}$ (suppressing, for simplicity, the dependence on the information set) as:

$$\begin{aligned} f\left(\mathrm{r}_{\tau_1}, \ldots, \mathrm{r}_{\tau_2}\right) &= \prod_{\tau=\tau_1}^{\tau_2} f(\mathrm{r}_{i\tau}, \mathrm{r}_{m\tau} | \mathrm{r}_{i\tau-1}, \mathrm{r}_{m\tau-1}) \\ &= \prod_{\tau=\tau_1}^{\tau_2} f(\mathrm{r}_{i\tau} | \mathrm{r}_{m\tau}, \mathrm{r}_{i\tau-1}, \mathrm{r}_{m\tau-1}) f(\mathrm{r}_{m\tau} | \mathrm{r}_{i\tau-1}, \mathrm{r}_{m\tau-1}) \end{aligned} \tag{11}$$

---

[3] This procedure implicitly assumes that market returns are not affected by the event, a hypothesis also adopted in all event studies that rely on the estimation of the market model. This seems a plausible assumption since the index is a weighted average of the prices of approximately 60 securities and each of them has, in general, a small weight in the index.

Let $\mathrm{r}_{i,-\tau} = \left(\mathrm{r}_{i\tau_1}, \ldots, \mathrm{r}_{i\tau-1}, \mathrm{r}_{i\tau+1}, \ldots, \mathrm{r}_{i\tau_2}\right)$, namely, the whole vector of unobservable acquirers' returns over the event window excluding $\mathrm{r}_{i\tau}$. Note that the posterior density of $\mathrm{r}_{i\tau}$ is non-standard and proportional to

$$p\left(\mathrm{r}_{i\tau} \middle| \mathrm{r}_{i,-\tau}\right) \infty f(\mathrm{r}_{i\tau}|\mathrm{r}_{m\tau}, \mathrm{r}_{i\tau-1}, \mathrm{r}_{m\tau-1}) f(\mathrm{r}_{i\tau+1}|\mathrm{r}_{m\tau+1}, \mathrm{r}_{i\tau}, \mathrm{r}_{m\tau}) f(\mathrm{r}_{m\tau+1}|\mathrm{r}_{i\tau}, \mathrm{r}_{m\tau}) \quad (12)$$

since $\mathrm{r}_{i\tau}$ enters into the formulas of the conditional distributions $f(\mathrm{r}_{i\tau+1}|\mathrm{r}_{m\tau+1}, \mathrm{r}_{i\tau}, \mathrm{r}_{m\tau})$ and $f(\mathrm{r}_{m\tau+1}|\mathrm{r}_{i\tau}, \mathrm{r}_{m\tau})$ through the conditional covariance.

However, we can sample from this non-standard density using, for instance, the Metropolis-Hastings algorithm. Let $\mathrm{r}_i = \left(\mathrm{r}_{i\tau_1}, \ldots, \mathrm{r}_{i\tau_2}\right)$ and denote by $\mathrm{q}\left(r'_{i\tau}, \mathrm{r}_{i\tau}|\mathrm{r}_{i,-\tau}\right)$ the candidate generating density, which we choose, for simplicity, as

$$\mathrm{q}\left(r'_{i\tau}, \mathrm{r}_{i\tau}|\mathrm{r}_{i,-\tau}\right) = f(\mathrm{r}_{i\tau}|\mathrm{r}_{m\tau}, \mathrm{r}_{i\tau-1}, \mathrm{r}_{m\tau-1})$$

The algorithm consists of the following steps:

Step 1: Set $\mathrm{r}_{i\tau_1}, \ldots, \mathrm{r}_{i\tau_2}$ to some arbitrary initial values $r_{i\tau_1}^{(0)}, \ldots, r_{i\tau_2}^{(0)}$

Step 2: For $m = 1, \ldots, M_0 + M$

For $\tau = \tau_1, \ldots, \tau_2$

(i) Draw

$$r'_{i\tau} \sim \mathrm{q}\left(r'_{i\tau}, \mathrm{r}_{i\tau}|r_{i\tau_1}^{(m)}, \ldots, r_{i\tau-1}^{(m)}, r_{i\tau+1}^{(m-1)}, \ldots, r_{i\tau_2}^{(m-1)}\right)$$

(ii) Compute

$$\psi \sim \frac{\mathrm{p}(r'_{i\tau}|\mathrm{r}_{i,-\tau})\mathrm{q}\left(\mathrm{r}_{i\tau}, r'_{i\tau}|r_{i\tau_1}^{(m)}, \ldots, r_{i\tau-1}^{(m)}, r_{i\tau+1}^{(m-1)}, \ldots, r_{i\tau_2}^{(m-1)}\right)}{\mathrm{p}(\mathrm{r}_{i\tau}|\mathrm{r}_{i,-\tau})\mathrm{q}\left(r'_{i\tau}, \mathrm{r}_{i\tau}|r_{i\tau_1}^{(m)}, \ldots, r_{i\tau-1}^{(m)}, r_{i\tau+1}^{(m-1)}, \ldots, r_{i\tau_2}^{(m-1)}\right)}$$

(iii) Set

$$r_{i\tau}^{(m)} = \begin{cases} r'_{i\tau} & if \quad Unif(0,1) \leq min\{\psi, 1\} \\ r_{i\tau}^{(m-1)} & \qquad otherwise \end{cases}$$

Step 3: Return $r_i^{(1)}, \ldots, r_i^{(M)}$.

The samples generated by the Markov chain converge to the joint posterior distribution $f\left(r_{\tau_1}, \dots, r_{\tau_2}\right)$ as $m$ increases. I discard the first $M_0$ samples as *burn-in* and use the last $M$ samples to construct simulated abnormal returns for the $i$-th security under the null hypothesis, denoted by $\widehat{ar}_{i\tau}^{(m)}$, and, in a manner similar to equations (9) and (10), simulate cumulative abnormal returns for security $i$ and across the $N$ securities, denoted, respectively, by $\widehat{car}_i^{(m)}(\tau_1, \tau_2)$ and $\overline{car}^{(m)}(\tau_1, \tau_2)$.

The $p$ value of the statistic is given by

$$p = \frac{1}{M} \sum_{m=1}^{M} I\left(\overline{car}(\tau_1, \tau_2) < \overline{car}^{(m)}(\tau_1, \tau_2)\right) \tag{13}$$

$P$ values associated with the null hypotheses that $\widehat{\mathrm{ar}}_{i\tau}$ and $\widehat{\mathrm{car}}_i(\tau_1, \tau_2)$ equal 0 can be derived in a similar way, if desired.

## 6. Empirical Results

### *6.1. Evidence of the Inadequacy of Some Commonly Used Univariate Models to Model the Dynamics of Returns*

Table 2 presents the results of specification and diagnostic tests applied to some univariate models commonly used to model the dynamics of returns. The estimation window consists of the returns in the 1,237 days preceding the 15-day window around the merger announcement.

The second column of the table shows the results of the Jarque-Bera test of normality of the errors of a simple market model. This model, reviewed by MacKinlay (1997), was extensively used in early event studies and consists of a simple linear regression of the returns of the $i$-th security on the market returns. It assumes a constant beta over time and that the errors are i.i.d. and normally distributed. The observed values of the statistic, with the exception of Suzano Bahia Sul, Net and Cyrela, provide strong evidence against the null hypothesis of normality of the errors even at the conservative level of significance of 1%.

The third column of Table 2 presents the results of the Jarque-Bera test of normality of the standardized errors of a GARCH(1,1) model, which relaxes the assumption of conditional homoscedasticity of the errors and accounts for time-varying volatility and volatility clustering, which are well-known features of financial time-series. Overall, we observe a reduction in the observed values of the statistic, but they still suggest that the standardized errors are not adequately modeled by a normal distribution.

A natural way to accommodate fat tails in the distribution of the errors is to posit a GARCH(1,1) specification with Student-*t* innovations for the errors in the market model. The normal and the Student-*t* distribution, however, are not nested, which precludes the use of a simple likelihood ratio test in the comparison of the models. Fortunately, Schennach and Wilhelm (2017) recently developed a simple model selection test for choosing among two parametric likelihoods, which can be applied in this more general setting without any assumptions on the relation between the candidate models and the true distribution and yields a test statistic that is distributed asymptotically as a standard normal distribution.

**Table 2 - Diagnostic and Specification Tests for Alternative Univariate Models Fitted to Daily Returns**

| Company | Jarque-Bera$^1$ | Jarque-Bera$^2$ | Schennach-Wilhelm Test | LR Test | Hansen LW Test |
|---|---|---|---|---|---|
| Suzano Bahia Sul | 1,32 | 0,68 | 0.2019 | 2.0926 | 4.4931* |
| VCP | 36,28** | 15,32** | 0.9663 | 0.7857 | 3.0431 |
| Suzano Petroquímica | 17,98** | 3,70 | 0.9322 | 0.0118 | 5.4877* |
| NET | 4,24 | 4,94 | 0.5426 | 1.2032 | 2.4681 |
| Braskem | 70,63** | 26,86** | 1.9462* | 0.2647 | 6.2505** |
| Unipar | 96,22** | 50,24** | 2.7691** | 0.0317 | 4.9949* |
| Vivo | 337,94** | 324,56** | 2.3918** | 2.9819 | 6.7595** |
| Perdigão | 381,20** | 48,56** | 1.2379 | 0.0472 | 13.0179** |
| Oi | 5919,93** | 6928,24** | 1.9859* | 2.3899 | 2.5919 |
| Gerdau Metalúrgica | 22,20** | 10,18** | 0.7373 | 0.8140 | 13.8355** |
| Cyrela | 8,61* | 9,58** | 1.1149 | 22.3348** | 4.7509* |
| Totvs | 710,70** | 755,90** | 1.6412 | 0.7287 | 1.5856 |
| Gafisa | 2986,67** | 7,29* | 0.8589 | 24.7133** | 8.8360** |
| Brascan | 277,39** | 129,44** | 1.7492* | 0.5787 | 3.0792 |
| VCP | 146,83** | 113,21** | 0.9842 | 4.7155* | 7.1364** |
| Itaú | 127,42** | 35,30** | 0.9962 | 0.9171 | 10.5061** |
| Perdigão | 247,62** | 18,50** | 0.7816 | 0.1642 | 4.1082* |
| Pão de Açúcar | 63,56** | 46,92** | 1.9881* | 1.1195 | 2.3824 |
| Duratex | 181,49** | 23,30** | 1.4471 | 1.1657 | 12.3698** |
| Amil | 365,52** | 47,98** | 2.5192** | 13.7194** | 2.3503 |

**Table 2 - Diagnostic and Specification Tests for Alternative Univariate Models Fitted to Daily Returns (continuation)**

| Company | Jarque-Bera$^1$ | Jarque-Bera$^2$ | Schennach-Wilhelm Test | LR Test | Hansen LW Test |
|---|---|---|---|---|---|
| Braskem | 331,55** | 285,43** | 2.4404** | 0.1369 | 6.9613** |
| PDG Realty | 131,30** | 33,11** | 1.4811 | 0.5494 | 4.2463* |
| Cemig | 137,05** | 48,16** | 1.4154 | 0.8495 | 26.7942** |
| Drogasil | 103,05** | 106,18** | 1.8480* | 0.5239 | 3.3751 |
| Cosan | 390,04** | 192,88** | 2.8084** | 6.4203* | 5.7722** |
| Kroton | 11705,55** | 370,03** | 2.8847** | 3.0196 | 6.3863** |
| BM&FBovespa | 55,08** | 42,24** | 2.0763* | 0.6842 | 2.2134 |
| Kroton | 592,23** | 194,56** | 3.2623** | 22.1392** | 16.0229** |
| Suzano | 185,53** | 210,60** | 2.1237* | 12.2040** | 7.7338** |
| Cogna | 424,82** | 185,32** | 2.5898** | 20.6401** | 10.2044** |
| Aliansce | 629,94** | 468,74** | 2.3981** | 4.9962* | 4.4648* |

The second column of the table shows the results of the Jarque-Bera test of normality of the errors of the market model. The third column presents the results of this same test for an extended market model with GARCH(1,1) normal errors. The fourth column exhibits the results of the Schennach-Wilhelm test of the null hypothesis that the GARCH(1,1) model with normal errors adequately describes the return dynamics against the alternative that replaces the normal distribution by the Student-*t* distribution. The fifth column shows the results of a likelihood ratio test applied to discriminate between a symmetric and an asymmetric GARCH(1,1) model with Student-*t* errors. The last column presents the observed values of Hansen LW test of the null hypothesis of constancy of the intercept and of the slope in the regression equation in the asymmetric GARCH(1,1) model with Student-*t* errors. ** and * denote significance at the 1% and 5% levels, respectively.

The fourth column of Table 2 applies Schennach and Wilhelm's statistic to test the null hypothesis of a GARCH(1,1) model with normal errors against a GARCH(1,1) model with Student-*t* innovations. We can observe that, for 16 of the 31 securities, we can reject the null hypothesis at the 5% level, which indicates that the results of the Jarque-Bera tests may be driven by the presence of fat-tails in the return distributions. But for 11 of the remaining securities for which there is evidence of non-normality of the errors, the Schennach and Wilhelm's statistic does not provide evidence that allowing for fat-tails in the distribution improve the fit of the model.

The above findings led me to subsequently fit an asymmetric GARCH(1,1) model with Student-*t* innovations, which enables the level of volatility to respond differently to positive and negative shocks to returns. Since this model nests the previous one, their fit can be compared through a likelihood ratio test, which is asymptotically distributed as a $\chi^2$ distribution with one degree of freedom. The results, shown in the fifth column of Table 2, indicate that, for nine of the 31 securities, we can reject the null hypothesis of a GARCH(1,1) model with symmetric Student-*t* errors against the alternative at the 5% level of significance and, for six of them, at the 1% level. This indicates that the incorporation of an asymmetric impact of shocks is important to describe the dynamics of returns.

Finally, in the sixth column of Table 2, I apply the LW statistic proposed by Hansen (1990) to test the null hypothesis of constancy of the intercept and of the slope in the regression of the *i*-th security return on the market return under the assumption that the innovations follow an asymmetric GARCH(1,1) model with Student-*t* errors. The distribution of the test statistic is non-standard and its critical values are tabulated in Table 3 in Hansen (1990). Comparing the observed values of the statistic with the critical values of 4.05 and 5.65 associated, respectively, with the 5% and 1% levels of significance for two degrees of freedom, we can reject the null hypothesis of constancy of the parameters for 22 of the 31 securities at the 5% level and for 15 securities at the 1% level.

In sum, the results of the specification and diagnostic tests of the univariate models, taken together, provide evidence that they do not adequately model the dynamics of returns and that the incorporation of time-varying betas is crucial, which reinforces the need for a more general model such as the full bivariate asymmetric BEKK model with Student-*t* errors proposed in Section 4.

### *6.2. Estimates from the Asymmetric BEKK Model with Student-t Errors*

Table 3 presents the maximum likelihood estimates of the coefficients for the benchmark specification, the bivariate asymmetric BEKK model with Student-*t* errors. We observe that, in general, the diagonal terms of B are large and close to 1.0, which provides evidence that the conditional covariances of the returns of acquirers and of the market are mainly driven by their own past values. In addition, we note that several of the diagonal elements of G are statistically different from zero, which suggests that the incorporation of leverage effects is important to model the dynamics of the conditional covariance matrix.

Table 3 – Maximum Likelihood Estimates of the Parameters of the Bivariate Asymmetric BEKK Model with Student-$t$ Errors

| Company | μ | C | | A | | B | | G | | v | Maximum Eigenvalue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Suzano Bahia Sul | 0.1197 | 0.0350 | | 0.1319 | -0.0610 | 0.9953 | -0.0190 | 0.0900 | -0.1779 | | 0.9943 |
| | (0.1115) | (0.1325) | | (0.0524) | (0.0684) | (0.0089) | (0.0186) | (0.0907) | (0.0698) | 31.6810 | |
| | 0.1829 | -0.2590 | 0.0000 | 0.0185 | 0.0120 | 0.0243 | 0.9446 | -0.1421 | -0.1913 | (29.3915) | |
| | (0.0848) | (0.1515) | (1.1536) | (0.0739) | (0.0995) | (0.0130) | (0.0303) | (0.0511) | (0.0794) | | |
| VCP | 0.1160 | 0.2732 | | 0.1475 | -0.0682 | 0.9785 | -0.0096 | -0.1536 | 0.2098 | | 0.9990 |
| | (0.0657) | (0.0841) | | (0.0408) | (0.0542) | (0.0087) | (0.0124) | (0.0718) | (0.0652) | 21.3919 | |
| | 0.0751 | 0.3354 | 0.0000 | 0.0499 | 0.0527 | -0.0160 | 0.9678 | -0.0315 | 0.2780 | (7.9797) | |
| | (0.0583) | (0.0867) | (0.6739) | (0.0434) | (0.0554) | (0.0094) | (0.0125) | (0.0707) | (0.0632) | | |
| Suzano Petroquímica | -0.0714 | 1.6212 | | 0.5599 | -0.8042 | 0.4147 | 0.3820 | 0.1230 | 0.2333 | | 0.9914 |
| | (0.1805) | (0.3885) | | (0.1304) | (0.2021) | (0.2745) | (0.2465) | (0.2392) | (0.3875) | 31.5988 | |
| | 0.0476 | -0.0130 | 0.0000 | 0.0317 | -0.0664 | -0.0290 | 1.0061 | 0.0712 | 0.1393 | (36.0943) | |
| | (0.0995) | (0.2082) | (0.1615) | (0.0547) | (0.0997) | (0.0611) | (0.0379) | (0.0438) | (0.0917) | | |
| NET | 0.0326 | 1.2330 | | 0.4123 | -0.2713 | 0.5221 | 0.3771 | 0.4840 | 0.2593 | | 0.9561 |
| | (0.1535) | (0.2469) | | (0.1348) | (0.2058) | (0.1994) | (0.2577) | (0.2619) | (0.3306) | 17.6626 | |
| | 0.0775 | -0.0819 | 0.0000 | 0.1473 | -0.1652 | -0.0532 | 0.9970 | 0.0920 | 0.2689 | (13.8316) | |
| | (0.0958) | (0.2009) | (1.7875) | (0.0537) | (0.1248) | (0.0815) | (0.0694) | (0.1086) | (0.1605) | | |
| Braskem | 0.0268 | 0.6433 | | 0.2809 | 0.0259 | 0.9440 | -0.0607 | -0.0952 | 0.3903 | | 0.9540 |
| | (0.0758) | (0.1390) | | (0.0584) | (0.0757) | (0.0392) | (0.0798) | (0.1143) | (0.1877) | 15.1985 | |
| | 0.0991 | 0.1811 | 0.3153 | -0.0104 | 0.0871 | 0.0343 | 0.9101 | -0.0918 | 0.4138 | (3.7804) | |
| | (0.0447) | (0.1375) | (0.0673) | (0.0291) | (0.0582) | (0.0163) | (0.0245) | (0.0532) | (0.0709) | | |
| Unipar | 0.1042 | 0.6278 | | 0.3118 | 0.0015 | 0.8912 | -0.0473 | -0.1062 | 0.4576 | | 0.8947 |
| | (0.0535) | (0.1324) | | (0.0655) | (0.0949) | (0.0598) | (0.1010) | (0.1762) | (0.1349) | 11.6950 | |
| | 0.1797 | 0.0099 | 0.5821 | -0.1035 | 0.1137 | 0.1309 | 0.8013 | -0.0169 | 0.3297 | (2.5019) | |
| | (0.0438) | (0.2085) | (0.1198) | (0.0484) | (0.0631) | (0.0650) | (0.0800) | (0.0965) | (0.0932) | | |
| Vivo | -0.0228 | 1.2289 | | 0.3705 | -0.0827 | 0.7183 | 0.3316 | 0.1305 | 0.0892 | | 0.9567 |
| | (0.0791) | (0.1906) | | (0.0678) | (0.1276) | (0.0952) | (0.1521) | (0.1740) | (0.2080) | 9.7159 | |
| | 0.1697 | -0.1461 | 0.4274 | -0.0255 | 0.1498 | 0.0753 | 0.8237 | 0.0592 | 0.2618 | (1.5940) | |
| | (0.0426) | (0.1252) | (0.0867) | (0.0336) | (0.0582) | (0.0614) | (0.0970) | (0.0809) | (0.1321) | | |

| Company | μ | C | | A | | B | | G | | v | Maximum Eigenvalue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Perdigão | 0.2228 | 0.5886 | | 0.3124 | -0.0421 | 0.9247 | -0.0285 | 0.1380 | 0.1268 | | 0.9623 |
| | (0.0657) | (0.1144) | | (0.0474) | (0.0557) | (0.0241) | (0.0283) | (0.0883) | (0.0998) | 14.0207 | |
| | 0.1655 | 0.2525 | 0.2366 | 0.0443 | 0.0364 | (-0.0120 | 0.9569 | 0.0241 | 0.2715 | (3.0816) | |
| | (0.0427) | (0.0876) | (0.0818) | (0.0257) | (0.0493) | (0.0107) | (0.0128) | (0.0315) | (0.0471) | | |
| Oi | 0.0220 | 0.5481 | | 0.1473 | -0.1592 | 0.9761 | -0.0455 | 0.0699 | 0.2940 | | 0.9531 |
| | (0.0677) | (0.1973) | | (0.0616) | (0.0950) | (0.0353) | (0.0463) | (0.1035) | (0.1338) | 8.3908 | |
| | 0.1579 | 0.3350 | 0.3139 | -0.0278 | 0.0964 | 0.0164 | 0.9025 | 0.0527 | 0.3224 | (1.1315) | |
| | (0.0429) | (0.1372) | (0.0902) | (0.0363) | (0.0693) | (0.0230) | (0.0305) | (0.0776) | (0.1048) | | |
| Gerdau Metalúrgica | 0.2361 | 0.4774 | | -0.0921 | 0.1190 | 0.9862 | -0.0861 | 0.2484 | 0.1804 | | 0.9924 |
| | (0.0599) | (0.1036) | | (0.0860) | (0.0873) | (0.0208) | (0.0278) | (0.0709) | (0.0927) | 17.7153 | |
| | 0.1590 | 0.3562 | 0.1302 | -0.1617 | 0.2391 | 0.0066 | 0.9135 | 0.0376 | 0.3247 | (5.0066) | |
| | (0.0421) | (0.0650) | (0.0426) | (0.0491) | (0.0627) | (0.0164) | (0.0228) | (0.0614) | (0.0828) | | |
| Cyrela | 0.1809 | 1.3794 | | 0.3275 | -0.0725 | 0.7824 | 0.1600 | 0.1145 | 0.4382 | | 0.9238 |
| | (0.1167) | (0.2258) | | (0.0720) | (0.1486) | (0.0624) | (0.0978) | (0.1079) | (0.1645) | 13.7477 | |
| | 0.1407 | 0.2393 | 0.0000 | 0.1045 | -0.0690 | -0.0862 | 0.9943 | 0.0755 | 0.3888 | (4.1663) | |
| | (0.0560) | (0.1278) | (0.4718) | (0.0339) | (0.0758) | (0.0194) | (0.0228) | (0.0495) | (0.0779) | | |
| Totvs | 0.0582 | 1.6409 | | 0.4095 | -0.1874 | 0.4958 | 0.2362 | -0.3466 | 0.4982 | | 0.9203 |
| | (0.0895) | (0.2096) | | (0.0852) | (0.1360) | (0.1518) | (0.1283) | (0.1756) | (0.1871) | 6.9980 | |
| | 0.1303 | 0.0222 | 0.4836 | -0.0153 | 0.1200 | -0.0297 | 0.9091 | -0.0042 | 0.4789 | (1.3860) | |
| | (0.0628) | (0.1387) | (0.1239) | (0.0492) | (0.0808) | (0.0842) | (0.0535) | (0.0822) | (0.0855) | | |
| Gafisa | 0.0429 | 0.4412 | | 0.1687 | 0.2126 | 0.9577 | -0.0958 | -0.3200 | 0.7979 | | 0.9367 |
| | (0.1149) | (0.2235) | | (0.0584) | (0.1199) | (0.0372) | (0.1038) | (0.1242) | (0.1631) | 12.8456 | |
| | 0.1075 | -0.6086 | -0.0018 | -0.0905 | 0.1322 | 0.1073 | 0.7197 | -0.2561 | 0.7043 | (3.1848) | |
| | (0.0614) | (0.1084) | (1.2216) | (0.0445) | (0.0887) | (0.0303) | (0.0688) | (0.0651) | (0.1032) | | |
| Brascan | -0.1846 | 0.6894 | | 0.1286 | 0.4429 | 0.9124 | -0.6095 | -0.1679 | 0.4301 | | 0.9600 |
| | (0.1138) | (0.3421) | | (0.0547) | (0.0877) | (0.0514) | (0.0809) | (0.1276) | (0.1328) | 10.3612 | |
| | 0.1265 | 0.2924 | 0.0000 | -0.0404 | 0.0543 | 0.2587 | 0.7622 | 0.0126 | 0.3280 | (3.1339) | |
| | (0.0728) | (0.3739) | (1.4622) | (0.0329) | (0.0646) | (0.0331) | (0.0329) | (0.0806) | (0.0814) | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VCP | 0.0392 | 0.4315 | | 0.2207 | -0.0355 | 0.9667 | -0.0603 | 0.0047 | -0.2965 | | 0.9249 |
| | (0.0559) | (0.1968) | | (0.0542) | (0.0691) | (0.0525) | (0.0789) | (0.0994) | (0.0994) | 16.8900 | |
| | 0.1303 | 0.0220 | 0.5465 | 0.0082 | 0.0058 | 0.0754 | 0.8421 | -0.1203 | -0.3022 | (4.2534) | |
| | (0.0442) | (0.2748) | (0.1154) | (0.0549) | (0.0785) | (0.0511) | (0.0620) | (0.0627) | (0.0706) | | |
| Itaú | 0.1028 | 0.1798 | | -0.0504 | 0.2474 | 1.0117 | -0.0868 | 0.2832 | 0.0555 | | 0.9922 |
| | (0.0560) | (0.1442) | | (0.0541) | (0.0600) | (0.0195) | (0.0318) | (0.0799) | (0.1103) | 17.7638 | |
| | 0.1032 | 0.2919 | 0.2017 | -0.1946 | 0.3059 | 0.0492 | 0.8741 | 0.0632 | 0.3134 | (4.8926) | |
| | (0.0440) | (0.1496) | (0.1566) | (0.0435) | (0.0645) | (0.0229) | (0.0331) | (0.0896) | (0.1094) | | |
| Perdigão | 0.1481 | 0.5475 | | 0.2474 | -0.0764 | 0.9412 | -0.0165 | 0.1619 | 0.2006 | | 0.9745 |
| | (0.0724) | (0.1374) | | (0.0559) | (0.0752) | (0.0242) | (0.0191) | (0.0659) | (0.0802) | 18.4645 | |
| | 0.1032 | 0.2144 | 0.2081 | 0.0287 | -0.0150 | -0.0103 | 0.9602 | 0.0195 | 0.3373 | (5.0700) | |
| | (0.0462) | (0.0616) | (0.0432) | (0.0308) | (0.0603) | (0.0117) | (0.0110) | (0.0287) | (0.0460) | | |
| Pão de Açúcar | 0.0190 | 1.1598 | | 0.3322 | -0.3085 | 0.7145 | 0.0875 | -0.0167 | 0.4842 | | 0.9835 |
| | (0.0601) | (0.2976) | | (0.1274) | (0.0938) | (0.1749) | (0.0904) | (0.1003) | (0.1227) | 12.3505 | |
| | 0.1175 | 0.3248 | 0.0408 | 0.0525 | 0.0068 | -0.1109 | 1.0054 | -0.0229 | 0.4207 | (2.5910) | |
| | (0.0458) | (0.0965) | (0.5458) | (0.0420) | (0.0729) | (0.0450) | (0.0255) | (0.0610) | (0.0613) | | |
| Duratex | 0.1491 | 0.8053 | | 0.2673 | 0.1897 | 0.8360 | 0.1057 | 0.3063 | -0.0576 | | 0.9740 |
| | (0.0714) | (0.1508) | | (0.0733) | (0.0945) | (0.0601) | (0.0788) | (0.1045) | (0.1499) | 16.9848 | |
| | 0.1085 | -0.0724 | 0.3495 | -0.0157 | 0.1095 | 0.0189 | 0.9236 | 0.0582 | 0.2977 | (4.6944) | |
| | (0.0453) | (0.0964) | (0.0858) | (0.0363) | (0.0635) | (0.0307) | (0.0407) | (0.0461) | (0.0767) | | |
| Amil | 0.0347 | 1.5884 | | 0.7054 | -0.6883 | 0.4829 | 0.2705 | 0.2111 | 0.0375 | | 0.9763 |
| | (0.1148) | (0.2589) | | (0.1154) | (0.0986) | (0.1195) | (0.0993) | (0.2544) | (0.2570) | 7.0310 | |
| | 0.0751 | -0.0252 | 0.3255 | 0.1123 | 0.0160 | -0.0760 | 0.9735 | -0.0193 | 0.4368 | (1.5403) | |
| | (0.0883) | (0.2004) | (0.2329) | (0.0625) | (0.0732) | (0.0645) | (0.0387) | (0.0856) | (0.1096) | | |
| Braskem | -0.1201 | 0.7667 | | 0.2740 | 0.0671 | 0.9066 | -0.0312 | -0.2202 | 0.5207 | | 0.9740 |
| | (0.0687) | (0.1322) | | (0.0523) | (0.0802) | (0.0302) | (0.0282) | (0.1020) | (0.1130) | 9.4937 | |
| | 0.1040 | 0.1905 | 0.2823 | -0.0064 | 0.1244 | 0.0139 | 0.9317 | -0.1339 | 0.4641 | (1.5437) | |
| | (0.0456) | (0.0808) | (0.0519) | (0.0336) | (0.0541) | (0.0203) | (0.0208) | (0.0507) | (0.0646) | | |
| PDG Realty | 0.1906 | 0.4605 | | 0.2378 | 0.1268 | 0.9579 | -0.0721 | 0.0565 | -0.5027 | | 0.9849 |
| | (0.1104) | (0.2554) | | (0.0487) | (0.1148) | (0.0295) | (0.0552) | (0.1775) | (0.1643) | 10.8907 | |
| | 0.1064 | -0.1138 | 0.1763 | 0.1198 | -0.1324 | 0.0199 | 0.9187 | 0.0121 | -0.4008 | (2.6680) | |
| | (0.0578) | (0.2296) | (0.1961) | (0.0445) | (0.0711) | (0.0266) | (0.0280) | (0.0516) | (0.0769) | | |
| Cemig | 0.0505 | 0.3112 | | 0.2278 | 0.0145 | 0.9608 | -0.0278 | 0.1091 | 0.1704 | | 0.9890 |
| | (0.0523) | (0.0809) | | (0.0470) | (0.0447) | (0.0112) | (0.0098) | (0.0827) | (0.0562) | 11.9257 | |
| | 0.0996 | 0.2277 | 0.1204 | 0.1529 | -0.0110 | -0.0226 | 0.9522 | -0.0225 | 0.4007 | (2.4850) | |
| | (0.0430) | (0.0625) | (0.0598) | (0.0440) | (0.0830) | (0.0118) | (0.0128) | (0.0718) | (0.0603) | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drogasil | 0.1157 | 1.4353 | | 0.3471 | 0.2081 | 0.5518 | 0.2021 | -0.0181 | 0.2127 | | 0.9361 |
| | (0.0820) | (0.1801) | | (0.0827) | (0.1135) | (0.1381) | (0.1276) | (0.1529) | (0.1474) | 10.0127 | |
| | 0.0221 | -0.2629 | 0.0000 | -0.0447 | 0.0759 | 0.2041 | 0.7908 | -0.0475 | 0.4202 | (2.5077) | |
| | (0.0513) | (0.1261) | (0.3319) | (0.0495) | (0.0755) | (0.0566) | (0.0756) | (0.0761) | (0.0887) | | |
| Cosan | 0.0522 | 0.1630 | | 0.0596 | -0.0449 | 0.9904 | -0.0368 | -0.2102 | -0.1256 | | 0.9983 |
| | (0.0630) | (0.0602) | | (0.0719) | (0.0839) | (0.0073) | (0.0147) | (0.0353) | (0.0637) | 9.7980 | |
| | 0.0200 | 0.1814 | 0.1383 | -0.0688 | 0.0265 | 0.0084 | 0.9459 | -0.0280 | -0.3320 | (1.6650) | |
| | (0.0416) | (0.0746) | (0.0764) | (0.0291) | (0.0739) | (0.0050) | (0.0114) | (0.0337) | (0.0514) | | |
| Kroton | 0.1523 | 0.6961 | | 0.3557 | -0.0974 | 0.8643 | 0.0235 | -0.0335 | 0.1229 | | 0.9808 |
| | (0.0540) | (0.0963) | | (0.0427) | (0.0562) | (0.0291) | (0.0166) | (0.1861) | (0.1075) | 7.7826 | |
| | -0.0198 | 0.0888 | 0.1795 | 0.0279 | 0.1268 | -0.0184 | 0.9650 | 0.0457 | 0.2728 | (1.1434) | |
| | (0.0402) | (0.0653) | (0.0510) | (0.0351) | (0.0408) | (0.0207) | (0.0106) | (0.0367) | (0.0583) | | |
| BM&FBovespa | 0.0004 | 0.5729 | | 0.2837 | -0.0268 | 0.8728 | 0.1024 | 0.0562 | 0.1455 | | 0.9888 |
| | (0.0567) | (0.1182) | | (0.0538) | (0.0731) | (0.0450) | (0.0525) | (0.0867) | (0.1097) | 13.9932 | |
| | -0.0642 | -0.1201 | 0.0000 | -0.0097 | 0.0063 | 0.0774 | 0.8880 | -0.0313 | 0.3449 | (3.1460) | |
| | (0.0383) | (0.0735) | (0.4458) | (0.0415) | (0.0767) | (0.0254) | (0.0349) | (0.0439) | (0.0589) | | |
| Kroton | 0.1762 | 0.2944 | | 0.2014 | -0.0347 | 0.9492 | 0.0341 | 0.2825 | -0.1583 | | 0.9885 |
| | (0.0567) | (0.0692) | | (0.0456) | (0.0715) | (0.0167) | (0.0268) | (0.0583) | (0.0809) | 9.4554 | |
| | -0.0412 | -0.0595 | 0.2008 | 0.0386 | 0.1612 | -0.0017 | 0.9650 | 0.0448 | -0.2217 | (1.6182) | |
| | (0.0402) | (0.0788) | (0.0634) | (0.0193) | (0.0376) | (0.0073) | (0.0116) | (0.0263) | (0.0560) | | |
| Suzano | 0.0461 | 0.5523 | | 0.1311 | -0.1784 | 0.9297 | 0.0059 | 0.3297 | -0.0096 | | 0.9716 |
| | (0.0580) | (0.0905) | | (0.0482) | (0.0687) | (0.0160) | (0.0251) | (0.0506) | (0.0817) | 9.2107 | |
| | 0.0492 | -0.0318 | 0.2218 | -0.0856 | 0.1203 | 0.0257 | 0.9498 | -0.0641 | 0.2953 | (1.4424) | |
| | (0.0370) | (0.0694) | (0.0787) | (0.0244) | (0.0520) | (0.0123) | (0.0126) | (0.0406) | (0.0549) | | |
| Cogna | 0.1034 | 0.2765 | | 0.0898 | 0.1967 | 0.9779 | -0.0459 | 0.2848 | -0.2926 | | 0.9906 |
| | (0.0626) | (0.0791) | | (0.0466) | (0.0592) | (0.0077) | (0.0160) | (0.0451) | (0.1001) | 9.2523 | |
| | 0.0524 | 0.2021 | 0.0377 | 0.0031 | 0.1814 | -0.0028 | 0.9673 | 0.0795 | -0.2163 | (1.4641) | |
| | (0.0376) | (0.0635) | (0.2314) | (0.0241) | (0.0436) | (0.0039) | (0.0075) | (0.0250) | (0.0656) | | |
| Aliansce | 0.0108 | 0.3961 | | 0.2010 | 0.0985 | 0.9545 | -0.0272 | -0.1393 | 0.1155 | | 0.9769 |
| | (0.0475) | (0.0731) | | (0.0765) | (0.0969) | (0.0247) | (0.0438) | (0.1128) | (0.1066) | 7.9331 | |
| | 0.0638 | 0.2135 | 0.1424 | -0.0248 | 0.1950 | 0.0101 | 0.9498 | -0.0852 | 0.2756 | (1.1004) | |
| | (0.0380) | (0.0732) | (0.0756) | (0.0389) | (0.0755) | (0.0171) | (0.0208) | (0.0862) | (0.1342) | | |

This table presents the maximum likelihood estimates of the parameters of the asymmetric BEKK model with Student-$t$ errors described by equations (1)-(3) in the text along with the respective standard errors for the returns of the 31 acquiring firms in the subsample used in this study and the corresponding market return over the 1,237 days immediately before the 15-day window around the merger announcement. The rightmost column of the table presents the maximum eigenvalue of $A\otimes A + B\otimes B + \frac{1}{2}G\otimes G$.

Turning now to the degrees of freedom of the Student t, the estimates vary from 6.9980 in the case of Totvs to 31.6810 for Suzano Bahia Sul, which indicates that the usefulness of relaxing the normality assumption of the innovations varies across securities. Finally, in the rightmost column of the table, I present the maximum eigenvalue of $(A\otimes A)+(B\otimes B)+1/2(G\otimes G)$, in absolute terms. In all cases, it is smaller than 1.0, which ensures stationarity of the model, as pointed out in Section 4.

In order to gain further insight into the importance of accounting for time-varying betas, I present, in Figure 2, the estimate of Itaú's beta from the benchmark model over the estimation window, from October 27, 2003 to October 22, 2008. The estimates of beta fluctuate widely, from a minimum of 0.5813 on January 14, 2005 to a maximum of 1.2752 on July 1, 2008. Even if we focus on shorter periods of time, we still observe huge oscillations in beta. From July 1, 2008 to July 21, 2008, for instance, in a window of only 14 trading days, beta declines sharply from 1.2752 to 0.6367, which confirms that the hypothesis that beta is invariant over the estimation window is inappropriate.

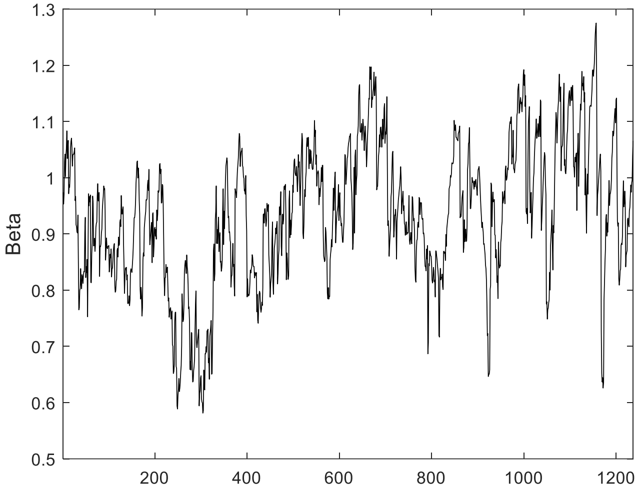

**Figure 2 - Itaú's Beta Estimate from the Asymmetric BEKK Model with Student-*t* Errors over the Period from October 27, 2003 to October 22, 2008**

This figure shows the evolution of Itaú's beta estimate from the asymmetric BEKK model with Student-*t* errors over the period from October 27, 2003 to October 22, 2008 based on a sample of 1,237 observations preceding the 15-day event window centered on the announcement of the merger on November 3, 2008. The time-varying beta is calculated as the ratio of $\widehat{H}_{12,t}$ and $\widehat{H}_{22,t}$, where $\widehat{H}_{12,t}$ and $\widehat{H}_{22,t}$ denote, respectively, the estimated conditional covariance of the errors in the bivariate model of Itaú and Ibovespa returns and the model estimated conditional variance of the errors of the Ibovespa return.

Finally, I present in Table 4 the results of the Kolmogorov-Smirnov test that compares the distribution of the standardized residuals $\left(r_{it} - \hat{\mu}_{1|2,t}\right)/\hat{\Sigma}^{1/2}_{1|2,t}$ to the Student-*t* distribution with the appropriate degrees of freedom, where $\hat{\mu}_{1|2t}$, and $\hat{\Sigma}_{1|2t}$, are given, respectively, by equations (6) and (7), and of the ARCH-LM statistic for a *k*-th order autoregression of squared standardized residuals ($k$ = 1, 3, 6 and 12). The observed values of the Kolmogorov Smirnov statistic are not statistically different from 0 even at the 10% level of significance. The associated *p* values range from 0.1286 to 0.9794, thereby not allowing us to reject the hypothesis that the distribution of the standardized residuals and the Student-*t* distribution are equal. In addition, there is no evidence that the squared errors, in general, are serially correlated. The average *p* values for lags 1, 3, 6 and 12 of the ARCH-LM test across the 31 bivariate estimated BEKK models equal, respectively, 0.5328, 0.5227, 0.4804 and 0.4828. We find lingering ARCH effects only in the squared residuals of Gerdau Metalúrgica, whose observed values of the statistic are significantly different from zero for lags 1, at a level of significance of 1%, and lags 3 and 6 at a level of significance of 5%.

Taken together, the results of the Kolmogorov-Smirnov and of the ARCH-LM tests suggest that the asymmetric BEKK model with Student-*t* errors provides a satisfactory description of the dynamics of daily returns.

**Table 4 – *P* Values of the Kolmogorov-Smirnov and of the ARCH-LM Tests Applied to the Asymmetric BEKK Model with Student-*t* Errors**

| | Kolmogov-Smirnov Statistic | ARCH-LM Statistic | | | |
|---|---|---|---|---|---|
| | | 1 Lag | 3 Lags | 6 Lags | 12 Lags |
| Mean | 0.6129 | 0.5328 | 0.5227 | 0.4804 | 0.4828 |
| Median | 0.5721 | 0.5690 | 0.4644 | 0.4140 | 0.4282 |
| Minimum | 0.1286 | 0.0063 | 0.0164 | 0.0307 | 0.0895 |
| Maximum | 0.9794 | 0.9917 | 0.9862 | 0.9910 | 0.9982 |

This table shows summary results of the Kolmogorov-Smirnov and of the ARCH-LM tests applied to the asymmetric BEKK model with Student-*t* errors. The second column of the table presents the observed values of the Kolmogorov-Smirnov statistic for equality of the distribution of $( r_{it} - \hat{\mu}_{1|2,t})/\hat{\Sigma}^{1|2}_{1|2,t}$, where $\hat{\mu}_{1|2t}$, and $\hat{\Sigma}^{1|2}_{1|2,t}$ are given, respectively, by equations (6) and (7), and the Student-*t* distribution with the appropriate degrees of freedom. The next four columns of the table exhibit summary statistics of the observed values of the ARCH-LM tests for a k-th order autoregression of squared standardized residuals (k = 1, 3, 6 and 12).

### *6.3. Impact of the Announcements of Mergers on the Market Value of Acquirers*

Figure 3 depicts the evolution of the average cumulative abnormal daily returns for acquirers over the 15-day event window centered on the merger announcement. Focusing initially on the results of the benchmark model, we see that the abnormal returns closely match the raw difference between the acquirers' and the market returns in Figure 1 and that the information about the acquisition is gradually revealed to market participants before its announcement.

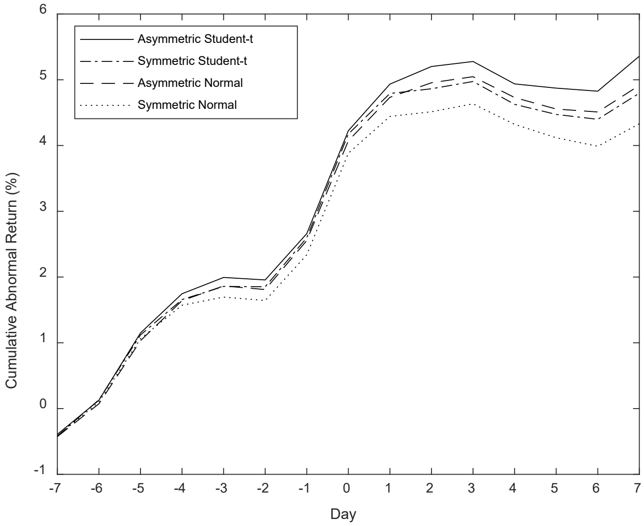

**Figure 3 – Average Cumulative Abnormal Compounded Daily Returns for Acquirers over the 15-Day Event Window Centered on the Merger Announcement**

This figure exhibits the evolution of the cumulative average abnormal daily return of the 31 acquiring firms in the sample over a 15-day window around the merger announcement. The abnormal compounded daily return for the i-th acquirer at any time t over the event window is computed as $\widehat{ar}_{it} = r_{it} - \hat{r}_{it}$, where $r_{it}$ and $\hat{r}_{it}$ denote, respectively, the observed and the predicted returns of the i-th acquirer at time t. $\hat{r}_{it}$ is estimated using the formula $\hat{r}_{it} = \hat{\mu}_1 + \widehat{H}_{12,t}\widehat{H}_{22,t}^{-1}(r_{mt} - \hat{\mu}_2)$. The cumulative abnormal return for the i-th acquirer between times $\tau_1$ = -7 and $\tau_2$ is calculated as $\widehat{car}_i(\tau_1, \tau_2) = \sum_{t=\tau_1}^{\tau_2} \widehat{ar}_{it}$ and the average cumulative abnormal return for acquirers is simply an arithmetic average of the individual cumulative abnormal returns.

In fact, most of the impact on stock returns is observed prior to and up to the date of the announcement. From day *t*=-7 to day *t*=0, the average cumulative abnormal return equals 4.2248%, which represents 78.84% of the overall effect of 5.3584% over the entire 15-day window. The *p* value associated with this average cumulative abnormal return of 5.3584% at *t*=7, computed using the procedure described in Section 5, is 0. Therefore, we can safely reject the null hypothesis of no impact of the announcement on acquirers' stock returns against the hypothesis of a positive effect. I note in passing that the critical values of this one sided test at 5% and 1% levels of significance are, respectively 1.9764% and 3.1489%, far below the observed value of the statistic. It is also worth emphasizing that 21 of the 31 acquiring firms experience positive cumulative abnormal returns over this 15-day window, which suggests that the documented impact is not attributable to very large positive cumulative abnormal returns of a few firms.

Finally, I present in Figure 3, for comparison purposes, the average cumulative abnormal returns for the competing BEKK models estimated in this paper. We observe that they display a pattern similar to that of the statistic for the benchmark model, although they increase as we move from the more restricted symmetric BEKK model with normal errors to the asymmetric BEKK model with Student-$t$ errors. If we inadvertently fit a symmetric BEKK model with normal errors to the data, for instance, we obtain an average cumulative abnormal return of 4.3306% at $t$=7, which underestimates the overall effect by approximately 20%.

The positive impact of the announcement documented in this paper is a *priori* consistent with the synergy and "chain letter" hypotheses. However, a deeper investigation of the trailing P/E ratios of acquirers and targets with positive earnings in the twelve months prior to the merger shows that the acquirers' median P/E ratio of 12.22 falls short of the targets' median P/E ratio of 16.03, which suggests that the "chain letter" hypothesis is not able to explain the documented positive returns.

This leads me to investigate the behavior of a couple of indicators of acquirers that may presumably be impacted by the presence of financial and operational synergies. Starting with operational synergies, I looked initially at the gross and EBIT margins in the trailing twelve months prior to the merger and prior to the fifth year after the announcement of those acquirers for which the information is available in both periods. There is an improvement in the gross margin of only six of 23 acquirers and in the EBIT margin of seven of 22 acquirers, which provides evidence that economies of scale, which reduce costs, are not driving the results.

We also do not observe an improvement in the return of acquirers after the merger. The return on equity and return on assets in the twelve months prior to the fifth year after the announcement are smaller than in the twelve months prior to the merger for, respectively, 20 and 19 of the 26 acquirers for which the comparison is possible, which indicates a deterioration in the profitability of most of the acquirers. This decline in the profitability is not accompanied by fastest sales growth.

The comparison of sales growth over the five-year period beginning twelve months after the quarter prior to the announcement with that in the five years prior to the announcement (which is restricted to 16 acquirers due to data availability) reveals that the median CAGR of 20.55% prior to the merger compares favorably with the median CAGR of -14.06% after the merger. For eight of the 16 acquirers, the sales growth after the merger exceeds that prior to the announcement.

Overall, these figures do not allow us to attribute the short-run positive returns to operational synergies that subsequently materialize.

I turn now to some indicators probably associated with financial synergies. For the 19 acquirers that report positive net earnings and positive earnings before taxes in both periods, there is an increase in the median effective tax rate, which rises from 15.24% in the twelve months prior to the announcement to 26.28% in the twelve months prior to the fifth year after the announcement. Moreover, for ten of the acquirers, we observe an increase in the effective tax rate. Therefore, the evidence does not seem to support, in general, the existence of financial synergies resulting from tax benefits.

Looking at capital expenditure as a fraction of total assets, we do not find evidence of financial synergies stemming from cash slack. 18 acquirers have data for the twelve months prior to the merger and the twelve months prior to the fifth year after the announcement. For these acquirers, the median ratio of capital expenditure to total assets equals 7.91% in the twelve months prior to the merger and 6.77% in the twelve months prior to the fifth year after the announcement.

Finally, it is worth noting that the ratio of the gross debt to equity from the quarter prior to the merger to the fifth year after the announcement increased for 17 of the 25 acquirers for which the comparison is possible. This indicator, however, is not directly informative of increased debt capacity in case borrowing constraints were not biding prior to the merger.

In sum, at least based on the evidence summarized in the previous paragraphs, we do not find evidence of operational and financial synergies and cannot rule out the possibility that short-run returns reflect market participants' misvaluation of the additional value acquiring firms may obtain from the synergies.

Previous findings in the literature summarized, for instance, in Jensen and Ruback (1983), suggest that mergers in the U.S. are zero net present value investments for acquiring firms. The majority of the studies used to compute these weighted averages, however, does not control for the size of the target. Restricting the analysis to transactions in which the target's equity value is 10% or more of the bidder's equity value, as in Asquith, Bruner and Mullins (1983), increases the average abnormal return for bidders over this same 21-day horizon to a statistically significant 4.1%, which is comparable to the estimate reported in this paper.

Turning now to the Brazilian evidence, it is worth mentioning the early attempt of Camargos and Barbosa (2006) to measure the impact of mergers and acquisitions on the stock returns of Brazilian firms, using a sample of 55 transactions that occurred between July 1994 and July 2002. The authors do not control for the relative size of the target. They estimate a simple market model and report an average cumulative abnormal return of 8.76% over a 41-day window centered on the announcement date.

All of the aforementioned results in the previous literature, nevertheless, suffer from the shortcomings pointed out in the Introduction, which potentially invalidate their conclusions.

### *6.4. Testing for the Presence of Asymmetric Effects and Fat Tails*

The second column of Table 5 shows the results of the likelihood ratio statistic for a test of the null hypothesis that the joint dynamics of returns are correctly modeled by a symmetric BEKK model with Student-$t$ errors against the alternative of an asymmetric BEKK model with Student-$t$ errors. That is, of the null hypothesis that all the parameters in the matrix G in equation (3) are simultaneously equal to zero. Since there are four parameters in the matrix, the statistic of the test is asymptotically distributed as a $\chi^2$ distribution with four degrees of freedom.

In all cases, with the exception of Suzano Petroquimica and NET, the symmetric BEKK model is rejected at the 5% level of significance and, in 27 of the 31 cases, the null hypothesis is rejected at the 1% level of significance. Thus, there is striking evidence that the innovations impact the volatility of returns asymmetrically.

The third column of Table 5 exhibits the results of a test for the comparison of an asymmetric BEKK model with normal errors with an asymmetric BEKK model with Student-*t* errors. Since the models are non-nested, I resort again to the Schennach-Wilhelm test.

We are able to reject the model with normal innovations in favor of the model with Student-*t* innovations in six of the 31 cases at the 5% level of significance. Therefore, it seems that, once we account for the asymmetric impact of shocks and time-varying betas, fat tails play an important role only for a small portion of the securities.

Finally, in the last column of Table 5, I present, for completeness, the results of a likelihood ratio test for the comparison of symmetric and asymmetric BEKK models with normal errors. The results provide strong evidence against the hypothesis that the innovations impact symmetrically the volatility of returns. We are able to reject the null hypothesis of a symmetric effect in 29 of the 31 cases at the 5% level of significance, with the exceptions of Suzano Petroquimica and NET, and for 28 of the 31 securities at the 1% level of significance.

**Table 5 - Results of Hypotheses Tests for the Presence of Asymmetric Effects and Fat Tails**

| | LR Test[1] | Schennach-Wilhelm Test | LR Test[2] |
|---|---|---|---|
| Significant at the 1% Level | 27 | 1 | 28 |
| Significant at the 5% Level | 29 | 6 | 29 |

This table presents the results of hypotheses tests for the presence of asymmetric effects and fat tails in the distribution of returns. The second column (LR Test[1]) shows the number of cases that the statistic of a likelihood ratio test of the null hypothesis that the dynamics of returns are correctly modeled by a symmetric BEKK model with Student-*t* errors against the alternative of an asymmetric BEKK model with Student-*t* errors are statistically significant at the 1% and 5% levels. The third column of the table presents analogous figures for the observed values of the Schennach-Wilhelm statistic for comparison of an asymmetric BEKK model with normal errors with an asymmetric BEKK model with Student-*t* errors. The fourth column of the table (LR Test[2]) shows the number of cases that the statistic of a likelihood ratio test of the null hypothesis of a symmetric BEKK model with normal errors against an asymmetric BEKK model with normal errors are statistically significant at the 1% and 5% levels.

### *6.5. Robustness of the Results to the Choice of Event Window*

In order to address the robustness of the results to the choice of event window, I re-estimate the model varying the length of the event window. More specifically, I consider the three-day, seven-day and 21-day windows centered around the announcement of the merger. In each case, the estimation window encompasses all returns prior to the initial date of the event window. The procedure proposed in Section 5 is then employed to simulate acquirers' returns in the absence of the merger and the respective average cumulative compounded daily returns.

Table 6 shows the estimates of abnormal cumulative average returns of acquirers for theses alternative windows of three, seven and 21 days around the merger announcement with the associated *p* values calculated using equation (13). For comparison purposes, I also included in the table the results for the 15-day benchmark window.

**Table 6 - Estimates of Average Cumulative Abnormal Daily Returns of Acquirers over Different Event Windows**

| Length of the Window | Cumulative Abnormal Return | *P* Value |
|---|---|---|
| 3-Days | 2.9672 | 0.0000 |
| 7-Days | 3.4789 | 0.0002 |
| 15-Days | 5.3584 | 0.0000 |
| 21-Days | 5.3073 | 0.0002 |

This table shows the estimates of the average cumulative abnormal daily returns of acquiring firms from the bivariate asymmetric BEKK model with Student-*t* errors over different window lengths. *P* values are calculated employing the procedure described in Section 5 based on M = 5,000 simulations.

It is apparent from the results in Table 6 that the positive response of stock returns to the merger announcement is not an artifact of the particular choice of the length of the event window. The three-day average cumulative abnormal return, for instance, equals 2.9672%, with an associated *p* value of 0.0000. Moving to the seven-day window results, we observe that the cumulative average abnormal return increases to 3.4789% and has a corresponding *p* value of 0.0002, remaining highly statistically significant.

Consistent with the evidence in Section 4, the effect seems to stabilize as the length of the window increases beyond 15 days. We can see that the 21-day window average cumulative abnormal return of 5.3073% is slightly lower than the corresponding figure of 5.3584% associated with the 15-day window, but it is still statistically different from zero at the 1% level, as indicated by the *p* value of 0.0002.

## 7. Conclusion

This paper applied an asymmetric BEKK model with Student-*t* errors to assess the impact of merger announcements on the market value of Brazilian acquiring firms. The model is sufficiently flexible to accommodate salient features of the data such as fat tails of returns, volatility clustering and time-varying betas.

Based on a sample of 31 mergers over the period 2004-2019 in which the market value of the target was at least 10% of the market value of the acquirer, I estimate a statistically and economically significant abnormal return to acquirers' stockholders over a 15-day window around the merger announcement, which equals 5.3584% and is primarily concentrated in the seven days prior to and at the date of the announcement. This suggests that the market anticipates the announcement of the transaction.

The evidence is, at first sight, consistent with the synergy and "chain letter" hypotheses in the merger literature. Nevertheless, an analysis of a couple of financial and accounting indicators of acquirers does not seem to support these hypotheses and does not rule out the possibility that the short-run returns documented in this paper reflect errors in the assessment of market participants of the additional value created by synergies.

The need to employ the more general model considered in this paper to correctly model the dynamics of stock returns is corroborated by the results of model diagnostic and specification tests. They provide strong evidence against univariate models commonly used in the literature and BEKK models with either normal errors or symmetric impact of the innovations on the conditional covariance matrix.

## References

Asquith, Paul. 1983. “Merger Bids, Uncertainty, and Stockholder Returns.” *Journal of Financial Economics* 11, no. 1-4: 51-83.

Asquith, Paul, Robert F. Bruner, and David W. Mullins Jr. 1983. “The Gains to Bidding Firms from Merger.” *Journal of Financial Economics* 11, no. 1-4: 121-39.

Bollerslev, Tim. 1987. “A Conditionally Heteroskedastic Time Series Model for Speculative Prices and Rates of Return”. *Review of Economics and Statistics* 69, no. 3 (August): 542-547.

Camargos, Marcos A. de, and Francisco V. Barbosa. 2006. “Eficiência Informacional do Mercado de Capitais Brasileiro Pós-Plano Real: Um Estudo de Eventos dos Anúncios de Fusões e Aquisições.” *Revista de Administração* 41, no. 1: 43-58.

Comte, Fabienne and Offer Lieberman. 2003. “Asymptotic Theory for Multivariate GARCH Processes”. *Journal of Multivariate Analysis* 84, no. 1 (January): 61-84.

Corhay, Albert and Alireza Tourani Rad. 1996. “Conditional heteroskedasticity adjusted market model and an event study.” *The Quarterly Review of Economics and Finance* 36, no. 4: 529-538.

Damodaran, Aswath. 2005. The Value of Synergy. New York: Stern School of Business.

Ding, Peng. 2016. “On the Conditional Distribution of the Multivariate t Distribution.” *The American Statistician* 70, no. 3 (July): 293-295.

Engle, Robert F., and Kenneth F. Kroner. 1995. “Multivariate Simultaneous Generalized ARCH”. *Econometric Theory* 11, no. 1 (March): 122--50.

de Jong, Frank., Angelien Kemna, and Teun Kloek. 1992. “A Contribution to Event Study Methodology with an Application to the Dutch Stock Market”. *Journal of Banking and Finance* 16, no. 1 (February): 11-36.

Hansen, Bruce E. 1990. “Lagrange Multiplier Tests for Parameter Instability in Non-Linear Models”. Department of Economics, University of Rochester, Rochester, New York. https://www.ssc.wisc.edu/~bhansen/papers/LMTests.pdf

Jensen, Michael C., and Richard S. Ruback. 1983. “The Market for Corporate Control: The Scientific Evidence.” *Journal of Financial Economics* 11, no. 1-4 (April): 5-50.

Kroner, Kenneth F., and Victor K. Ng. 1998. “Modeling Asymmetric Comovements of Asset Returns.” *Review of Financial Studies* 11, no. 4: 817-844.

Lettau, Martin, and Sydney Ludvigson. 2001. “Resurrecting the (C)CAPM: A Cross-Sectional Test When Risk Premia Are Time-Varying.” *Journal of Political Economy* 109, no. 6 (December): 1238-1287.

Lintner, John. 1971. “Expectations, Mergers and Equilibrium in Purely Competitive Securities Markets.” *American Economic Review* 61, no. 2 (May): 101-11.

MacKinlay, A. Craig. 1997. “Event Studies in Economics and Finance.” *Journal of Economic Literature* 35, no. 1 (March): 13-39.

Malatesta, Paul H. 1983. “The Wealth Effect of Merger Activity and the Objective Functions of Merging Firms.” *Journal of Financial Economics* 11, no. 1-4 (April): 155-81.

Mandelker, Gershon. 1974. “Risk and Return: The Case of Merging Firms.” *Journal of Financial Economics* 1, no. 4 (December): 303-335.

Mueller, Dennis C. 1969. “A Theory of Conglomerate Mergers.” *Quarterly Journal of Economics* 83, no. 4: 643-659.

Roll, Richard. 1986. “The Hubris Hypothesis of Corporate Takeovers.” *The Journal of Business* 59, no. 2 (April): 197-216.

Schennach, Susanne M., and Daniel Wilhelm. 2017. “A Simple Parametric Model Selection Test.” *Journal of the American Statistical Association* 112, no. 520: 1663-1674.