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A 10 min tick volatility analysis between the Ibovespa and the S&P500

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Abstract

In this paper we analyze intraday data on a 10-minute interval and compared the major market index in South America, the Ibovespa and sync up with the S&P500 in New York. The main target is to determine differences of volatility, in the Brazilian index, before and after the opening bell in New York. To reach this goal, we utilize the GARCH (autoregressive general heteroskedasticity) matching up times that both markets were open, and comparing to the hours that the Brazilian index was trading alone, without the direct influence of one of the American main indexes, the S&P500. As a result, we are able to disclose that this difference in volatility exists.

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1. Introduction

What daytraders know for a fact but academics do not, is that when Wall Street opens, many other markets throughout the globe come to life. In other words is that market fundamental concepts such as risk and return may change in some other countries, some are more susceptible than others, during their on-going trading session with the opening of the US Market. In this work we study and prove this phenomenon in the Brazilian main stock index the Ibovespa. Using the GARCH approach we demonstrate that the Brazilian market is more volatile when New York is closed and its volatility and persistence are altered after the opening bell in New York.

Experienced day traders operating in Latin markets will only start placing orders after the opening in New York and this is a common knowledge among trading professionals such as brokers, hedge fund managers, day traders, swing traders and so on. Market makers will dominate the trading before the opening in New York. This work aims to translate this common, almost cliché knowledge of market professionals, to academics. We analyzed intraday data, 10-minute tick, to compare the volatility between the main index in Brazil (Ibovespa) before and after the opening bell in New York, according to the GARCH approach. This work is based in the findings of Husain, (2005) which studied the volatility of the German DAX and the English Footsie and proved an increase of volatility in Europe, when New York opens. We found some similarities and insights in the work of Miralles *et al*. (2010) which found volatility spillovers between the US and the Spanish market.

This work sets as its main goal to prove that there is a difference in volatility of returns in Brazil after the opening of the US stock market, if compared to the period that only Brazil is open. The purpose is to have a better understanding of the dynamics that surround these two important markets and to shed some light on the effect that the American market inflicts to other peripheral markets, like the Brazilian, utilizing high frequency intraday data. And for that, we collected data from both markets since the beginning of 2013 until April of 2013 when this paper was written.

All trading days that both markets were open were taken into account and later were separated by the time both markets were open at the same time and the time that only the Brazilian market was operating. That varied during the sample because of daylight savings time but mainly the market in Brazil operates for 2.5 hours alone before the opening in New York. With that, we calculated the volatility before and after and later we will present the results demonstrating that the market in Brazil operated with more volatility before the S&P500 started to be traded.

2. Review of Literature

The GARCH methodology will be only glanced over in this paper, the financial world all know and the benefits of its applications are widely spread throughout professionals and academics. Since financial data is often leptokurtic, the general version of the ARCH (autoregressive conditional heteroskedasticity), (ENGLE, 1982) model gained the world of determining volatility or risk. According to Engle, traditional econometric models until then assumed a constant one-period variance and to generalize this incoherent assumption the ARCH was created where the past gives

information about the variance to forecast with serially uncorrelated with nonconstant variances but constant unconditional variances.

Having mentioned that, we will explain persistence, which refers to the property of a random variable of momentum in conditional variance (LAMOUREUX and LASTRAPES, 2000). More generally, modeling or forecasting different random variables such as futures or options depends on the perception of persistence or how long lasting shocks or innovations are to volatility.

Andersen and Bollerslev (1997) assert that standard time series models of volatility have proven inadequate when applied to high frequency data, mainly due to the variations of volume and bid-ask spreads throughout the trading day. Sokalska and Engle (2012) suggest the multiplicative component GARCH perhaps more suitable to model volatility when using high frequency data. However some previous results in literature are contradictory and do not establish that assumption. In this work we ignore the aforementioned systematic patterns pertinent to intraday data.

3. Data and methodological aspects

We collected intraday data of returns of both indexes with a 10-minute interval provided by Thompson Reuters, once again both markets are the S&P500 and the Ibovespa. We chose Brazil because is the main market in Latin America but in the future we intend to prove the same phenomena, studying other countries. The S&P500 was chosen because it´s well known importance and influence to other markets as proven by various studies, (SILK, 2012), (BECKER, FINNERTY AND GUPTA, 1990), (CURCI, CLARK AND BROWN 2001) and more recently (DUA and TUTEJA, 2013) which recently demonstrated the influence of this index in the Indian main index, the SENSEX.

The influence that Futures indexes of main American indexes such as the Dow Jones and the S&P500 exerts in other markets is clear for professional traders, and academically, has been proved by Chan, Chan and Karolyi (1991) and Abhyankar (1995). So we stress again the influence that futures in the United States would give to the Latin market, and even so after the opening bell we see more influence that the already inflicted by only the futures itself.

Summing up the everlasting presence of the futures index in America will affect markets and their return could be based by only the futures itself but the opening will affect even more with the index itself, in this case the S&P500 but the focus in this work is not the futures but the actual index fluctuations because if futures were not traded the results of this work, would be even more significant, so the futures index only acts as a muffler to what the index in America effects the index in Brazil.

The biggest challenge on sorting out the data was to organize and sync up market opening times of both countries. Normally Brazil opens almost 3 hours before New York but our sample was struck by a day light savings time. After that, the Brazilian market shifted to be opened alone for only less than1 hour, before the opening bell in New York. The time span is the first 14 weeks of 2013, adding up to 1818 observations of both markets opened at the same time and 324 observations of only

the Brazilian market opened. All holidays in each country and some days with inconsistent or abnormal data were excluded.

Brazilian bourse times start at 10:00 in the morning and New York will start in Brazil at 12:30 PM. These two and a half hours that Brazil operates solo is the time that we want to prove that is less volatile that the period from 12:30 to 18:00, the time that Brazil closes, and New York keeps going. On the 12th of March daylight savings time kicked in and Brazil went from 2.5 hours operating without the direct influence of New York to only half an hour of observations. This fact did not compromised this study because that period was only one week of observations of our sample, needless to say that we also considered the changing time and synced up the new operating times for both markets. All returns collected were transformed into log returns to eliminate stationarity; this is a standard procedure when utilizing financial database hence it will not be given any further explanation.

We modeled log-returns marginal through a *generalized auto-regressive conditional heteroskedasticity* – GARCH (1,1) model with student innovations, introduced by Bollerslev (1986) and largely applied in finance along the last decades, in order to consider the conditional heteroskedasticity, heavy-tailed behavior of the financial assets (Longin and Solnik, 2001), in other words, the applications of the GARCH methodology is one way to dribble inconstant variance in time series data. As mentioned before we will not explain thoroughly this methodology because it is spread out and widely diffused use in financial literature.

Below is the model we created to reach and prove our assumptions:

$$r_t = \alpha + \phi_1 r_{t-1} + \epsilon_t \qquad [1]$$
$$h_t = \theta + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$$

4. Results

Table 1 shows the results of intraday volatility of the Brazilian market, as per model GARCH(1,1). Based on these results, we verify that the parameters of the conditional mean equation were not significant, however the conditional variance equation were significant at 5% level. All parameters fit in this level Alpha, Beta and the Constant. The Akaike (AIC), Bayesian (BIC) and Hannan Quinn (HQC) criterion indicate that the GARCH (1,1) model is adequate.

After estimating the conditional volatility by the Garch model, we performed Anova and Mann-Whitney test to identify if there is a difference between the mean of the Ibovespa before and after the opening in New York. Both tests were carried out for the square returns as a proxy for instantaneous volatility and for the GARCH output, estimated in Table 1. For that we analyzed 1815 intraday observations in a 10 minute interval, being 324 only when New York is closed and 1491 when both markets are trading simultaneously.

The first test presented in Table 2 refers to Anova, a parametric type of test, which assumes normal distribution of the sample, and it is normally used to compare the

mean of two different and independent groups of variables. By this test, we verify that the mean and standard deviation of square returns for the times the American market is closed is 0.246 and 0.697 respectively. When both markets are open is 0.071 and 0.134. The volatility estimated by the GARCH model presented lower mean as well as smaller standard deviation, if compared with the squared returns. Therefore we indicate that when the American market is closed, the mean and standard deviation are 0.036 and 0.023. When New York is open this statistics are 0.025 and 0.007. At last, we performed an F test to diagnose if there is a difference between the volatility mean of the markets, with and without the influence of New York.

Table 1. GARCH(1,1) Student's t (n=1818) Variance/Covariance Robust

	Coefficient	Standard error	t-value	t-prob
Conditional mean equation				
Constant	-0.004	0.003	-1.240	0.215
AR(1)	-0.035	0.023	-1.519	0.129
AR(2)	0.015	0.023	0.660	0.509
AR(3)	-0.062	0.021	-2.947	0.003
Conditional variance equation				
Constant	0.003	0.001	4.462	0.000
Alpha	0.083	0.023	3.623	0.000
Beta	0.809	0.033	24.750	0.000
gl.	3.754	0.357	10.500	0.000
Information criterion				
AIC	-1878.480			
BIC	-1834.449			
HQC	-1862.234			

This result is 80.431 and p-value of 0.000 rejecting the null hypothesis of equal mean both for the squared returns and for the GARCH with 251.416 for the F test and p-value of 0.000.

Besides the Anova, we utilized the Mann-Whitney to compare both volatility means. This is a non-parametric type of test and is normally used to identify if two independent groups belong to the same population. To operationalize this test one need to classify the sample in ranks, occupied by elements n_1 and n_2 of the whole population. The null hypothesis (H_0) verifies if the median underlying to the population will be equal to median n_1 and n_2. Otherwise, H_0 is rejected. As per this analysis for the squared returns the sum of ranks is 345215 and 1065 when the American market is closed, whereas 1302805 and 874 when both markets are open.

The same test for the GARCH output shows a rank sum of 396235 and rank mean 1223 when Brazil is trading alone. And 1251785 and 840, when both markets are operating together. After that, we calculated the *Z* test for the squared returns with value of -5.967 and p-value of 0.000, rejecting the null hypothesis of the same volatility for the Brazilian market before and after the opening in New York. Moreover the *Z* value is -11.935 and p-value is 0.000, for the volatility estimated by

the GARCH method, then we confirm the results for both volatility models, in the same way the Anova test did.

Table 2. Mean difference of volatility pre and post opening of the U.S. market, 1815 observations (1818-3 of equations the mean)

ANOVA (parametric)

	U.S. market	Obs.	Mean	Std. deviation	F	sig
Ret^2	Closed	324	0.246	0.697	80.431	0.000
	Open	1491	0.071	0.134		
GARCH	Closed	324	0.036	0.023	251.416	0.000
	Open	1491	0.025	0.007		

Mann-Whitney (non-parametric)

	U.S. market	Obs.	Sum of ranks	Mean rank	Z	sig
Ret^2	Closed	324	345215	1065	-5.967	0.000
	Open	1491	1302805	874		
GARCH	Closed	324	396235	1223	-11.935	0.000
	Open	1491	1251785	840		

So based on the results found in this research, in tests Anova and Mann Whitney, the mean square return and the GARCH display greater values for the model which excluded the times that both markets were open at the same time. It only includes the interval that only the Brazilian market was open. There is a large difference of the mean volatility before and after the opening in New York.

5. Conclusion

Understanding interdependence between markets is tough; the relationships are complex and multidimensional. This work tries to shed some light onto the Brazilian case and its main stock market index, which gets propelled when the US market opens. Analyzing intraday data is not very much common, because of the difficulty of finding reliable data. Having said that, in times of high frequency trading, more academic studies using intraday database are surfacing and more are required, to give a spot-on, reading of current state and response to news and innovations.

At the end of this paper we are able to affirm that the volatility simmers down in Brazil after the opening of the US market. The sample period was a downward period for the index in Brazil, even though the Dow Jones grew stronger in the period, even hitting new highs, that did not translate to gains to the Brazilian index, the inability of the Brazilian government to make changes in taxation and infrastructure and laggish growth, shifted international focus and capital to more promising countries.

One thing we wanted to prove is that the opening bell in New York city could boost gains too, not only volatility but unfortunately the period chosen, the main index in Brazil went south, and as a suggestion for future studies is to pick a different period or a larger one, to determine if returns are also linked to the opening of the US market, and that would be very much valuable for trading desks throughout the world.

Another suggestion for further investigation, one should consider to execute the same analysis with a different type of GARCH variant, such as multiplicative component GARCH as suggested by Engle and Sokalska (2012), perhaps more suitable to model volatility when using high frequency data.

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