Financial Crisis of 2007-2009 and Stress Test with Structural Changes for the Brazilian Financial Market

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ABSTRACT

Due to the financial crisis of 2007-2009 and the serious problems still faced in particular by some countries in the Eurozone, we can check the current inseparability between financial and productive system. This context indicates the importance of analysis committed to measuring risk involving financial activities. Thus, the central objective of this work is to assess the stress effects of a financial distress in daily return series of the domestic market index on the daily return series of the major companies' assets in the Brazilian financial market, considering the period of international economic crisis and possible structural changes in the stress parameters. We use the methodology CoVaR, described by Adrian and Brunnermeier (2011), and analysis of structural changes in Quantile Regression (QR), highlighted by Qu (2008) and Oka and Qu (2011), to estimate the modifications in the stress test before and after of the last economic crisis. The main innovation of this study is to consider structural changes in the stress test, obtained by CoVaR for the quantiles 0.01, 0.05 and 0.10. The results show that some of the reaction coefficient of the returns of firms operating in the Brazilian financial market had structural changes, as well as the value at risk of the market index decreased between the two periods. In general, the marginal contribution of financial distress in the market index, independently of the quantile evaluated, generated a lower stress on the returns of firms after the international crisis than before of this adverse macroeconomic context.

Keywords: Stress Test, Quantile Regression, Structural Changes, Financial Crisis.

JEL codes: C21; G30; G32.

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1 - Introduction

In the last years, there was a fast advance of methodologies that aim to measure the risks to which the portfolios of many financial institutions and others firms operating in the markets are submitted. In a general way, those methodologies intend to provide quantitative support to the problem observed during the recent American crisis, which reverberated on the global market.

The traditional risk measurement, like Value at Risk (VaR) introduced by Leavens (1945), assesses the maximum loss of a given portfolio, in a determined period. Actually, we need of indicators that take into account the effects of negative externalities from an asset returns on the others. That way, the indicators proposed by the CoVaR methodology, which are described by Adrian and Brunnermeier (2011), have the advantage of conditioning the risk measures obtained by VaR to the worst losses also occurred in the other portfolios and financial market indicators. Arias, Mendoza and Perez-Reyna (2010) and Lima, Gaglianone and Oliver (2011) show many arguments by which the attributes of the risk measure provided by CoVaR make it possible to be used as a way of proper risk management in the financial markets.

However, the CoVaR model do not consider that structural breaks in the risk parameters motivated by alterations in economic context, for example, can affect the spillover effects. Recently, the global economy has seen one of the biggest crisis in history, in which the financial market had direct participation. Thus, we question whether the economic crisis was able to alter the risk measures as stress test obtained by CoVaR model.

In this context, the question of structural change has been focus in several studies. Since the works of Chow (1960), Fisher (1970), Gujarati (1970a; 1970b), Dufour (1980) and Burrows and Cantrell (1990) a variety of tests and applications have been made, specially, to verify structural change in the conditional mean function. Nevertheless, risk measures require evaluating at the negative extreme of the distribution, as well as an analysis whether the stress test on asset returns between different companies has changed over time.

In this direction, this work intend to calculate stress test, obtained by CoVaR model, with structural changes in quantile regression. Based in Qu (2008) and Oka and Qu (2011), we develop tests for structural break on daily return series of the major companies operating in the Brazilian financial market, considering possible effects of the economic crisis 2007-2009 on changes in the risk parameters. The innovation of this study is to incorporate structural changes in the CoVaR estimation.

Given the need for advances in the construction of types of measures for the risk management of domestic financial market, the present work assesses as a distress in the series of financial returns of national market indicator impacts the main returns of companies' assets that operate in BM&FBovespa. For this, the methodology CoVaR with structural changes was applied to the daily quotations data of the 16 assets selected from January 2003 to August 2011.

The paper is organized as follows. Section 2 shows the basic definition about CoVaR model, emphasizing the stress test measurement and the main equations to estimating the risk parameters with structural changes. Section 3 describes the dataset and Section 4 and 5 contain the central results.

2 - CoVaR model

The information which may be more relevant under the viewpoint of the regulation of markets is defended in the work of Adrian and Brunnermeier (2011) and, consequently in the present work. It is refer to the identification of marginal contribution of the risk existing in stock return series of a private company or portfolio for others, in relation to systemic risk and vice versa. As suggested by such authors, the estimation of CoVaR for quantile regressors – whose properties of robustness can be seen in Lima, Gaglianone and Oliver (2011) for the VaR case – makes this measure feature among the measures recently developed with an utmost degree of reliability.

In this sense, Adrian and Brunnermeier (2011) define the contribution of a determined institution for the systemic risk such as the difference between conditional CoVaR of the company asset that is under financial distress and CoVaR of returns of the asset on the median, i.e., quantile 50%. The prefix "Co", which was incorporated to VaR by the authors already mentioned, has wider coverage and it can be referred to conditionality, co-movement, contribution and contagion.

For this reason, it is a more robust and wider methodology than VaR, due to the possibility of capturing three fundamental aspects: the systemic risk, the contagion effect and stress test. Besides CoVaR, there is ΔCoVaR, whose aim is to measure the marginal contribution of a private institution for the global systemic risk. It consists of an assessment of the performance of portfolios by the difference of returns of the main companies that operate in financial market and market returns.

The regression estimated by quantiles, whose method was initially proposed by Koenker and Bassett (1978) is a type of regression used to carry out estimates based on several quantiles of a sample, i.e., through this method it is possible to obtain estimates approximated both of the median as of any other quantiles desired, from the dependent variable in analysis.

This way, it can be a tool to obtain a better information. They are not provided when it is used the Ordinary Least Squares Method (OLS), which, differently, provides estimates approximated of the conditional mean of the dependent variable based on determined values of the explanatory variables. In studies that use economic or financial data such as in this one, the models of quantile regression have been widely used, because they conduct to a more complete statistical analysis of stochastic relations among random variables (KOENKER, 2005).

This method has been spread in studies over the past few years, emerging as an approach for the statistical analysis of data through linear models, by expanding themselves in direction of non-linear models, widening, therefore, the possibilities of regression methods (KOENKER and MACHADO, 1999). Buchinsky (1998) and Koenker and Basset (1978) consider that one of the advantages of using the quantile regression to estimate the median, instead of OLS, is that the quantile regression result can be more robust, in response to outliers, for example, or distributions of residues which do not present normality.

In Lima, Gaglianone and Oliver (2011) the parameters of model VaR estimated through quantile regressions presented important properties concerning robust estimates. That was important in order to decide how to obtain the estimates of the several measures provided from the model CoVaR. Denoted by $CoVaR_q^{j|i}$, CoVaR, in this case, is VaR of the financial stock of company j, conditioned to some event C(X^i) to the stock of company i. In other words, $CoVaR_q^{j|i}$ is nothing but the q-n-to-default quantile of conditional probability distribution function. In this work, the quantiles analyzed were 1%, 5%, 10% and 50%, which mean the distribution median and the

other ones the negative extremes of returns distribution represent a financial distress scenario:

$$\Pr\left(X^j \leq CoVaR_q^{j|C(X^i)}|C\left(X^i\right)\right) = q \tag{2}$$

Thus, the proposal of Adrian and Brunnermeier (2011) was to generate a measure which could subsidize the monitoring of behavior from the returns of financial assets of the companies and identify those characterized by the impact caused from a higher negative externality (higher spillover effect) on the system and/or for the other assets. Even as the individual risk measures do not contain the information on externalities to they are subject, the marginal contribution was estimated, i.e., $\Delta CoVaR$ of the returns of asset *i* on asset *j* in an environment of financial distress. Therefore, it was possible to show how potential losses from *i* are transmitted to *j* and how the returns of companies suffer impacts of the main domestic index, as well as in which way they contribute to a distress in the returns of it.

The equation (3) shows the definition of $\Delta CoVaR$. It exhibits the marginal contribution of *i* to *j*, which is determined by the difference between the value at risk if *j* in the quantile q, conditioned to the value at risk of *i* in the same quantile and the value at risk of *j* in the quantile *q,* conditioned to the value at risk of *i* in the median.

$$\Delta CoVaR^{j|i} = CoVaR_q^{j|X^i=VaR_q^i} - CoVaR_q^{j|X^i=VaR_{50\%}^i} \tag{3}$$

where: $CoVaR_q^{j|X^i=VaR_q^i} = VaR_q^j|VaR_q^i$; $CoVaR_q^{j|X^i=VaR_{50\%}^i} = VaR_q^j|VaR_{50\%}^i$. These expressions show the definition of $\Delta CoVaR$. On the basis of the interaction and specification between the assets *i* and *j*, from this approach, it is possible to obtain three measures of risk management: systemic risk, stress test and contagion effect. However, this article will emphasize only stress test, including structural change in this risk measure.

2.2 Stress test with structural change

The stress test, which is a direct contribution of the work of Adrian and Brunnermeier (2011), can be defined as the marginal contribution to the vulnerability of the returns of company *i*, conditioned to a financial distress in the system (market returns). Therefore, it is different from the similar concept presented by Markowitz (1952). According to the convention used in this work, the stress test shows the negative externality of the lower quantiles of asset returns of a given company which operates in domestic financial market on the "market returns".

However, the traditional approach introduced by Adrian and Brunnermeier (2011) does not consider that any events can generate structural changes on the parameters of stress test. In the literature, we found classical studies as Chow (1960), Gujarati (1970a; 1970b) and Fisher (1970) on the statistical validation about structural changes in the parameters of economic models, for example, motivated by changes in economic (crisis and advances in productivity) and policy context (war and end of dictatorships). These studies were made tests for structural changes in linear regressions.

Recently, Qu (2008) and Oka and Qu (2011) developed tests for structural changes in quantile regression, because the changes, according to authors, can be different among the quantiles of the conditional distribution. In our case, we intend incorporate structural changes in the CoVaR estimation.

We consider the last international economic crisis between 2007 and 2009, as highlighted by NBER, as demarcation of a period that generated potential changes in the coefficients of the CoVaR model. Thus, we have, basically, two periods: before and after crisis.

In domestic case, it is possible to score the companies' that suffer the highest negative impacts, given by the worst losses in the market returns (captured by Ibovespa), in which the stress test is presented as another monitoring and management measure. For the estimation of $\Delta CoVaR^{i/M}$, it is firstly necessary to estimate VaR of the asset returns of company *I* conditioned to the value at risk of market return rate, M. Therefore, we calculate this equation using quantile regression with structural changes, in which *D* represents the crisis indicator (*D*=0, if before crisis, and *D*=1, if after crisis). By taking into account the definition of VaR, we have the following:

$$VaR_q^i | X^M = \hat{X}_q^{i,M} \tag{4}$$

where:

$$\hat{X}_q^{i,M} = \hat{\alpha}_q^M + \hat{\theta}_{0q} D + \hat{\beta}_q^M X_q^M + \hat{\theta}_{1q} D X_q^M \tag{5}$$

The term $\hat{X}_q^{i,M}$ denotes the value estimated for returns of company *i* in the quantile q conditioned to the market returns in the quantile q. In this scenario, the definition of value at risk of the company asset *i* conditioned to system M, $CoVaR^{i|X^M}$, to the *q*th quantile of distribution is given by the equation (6):

$$CoVaR^{i|X^M = VaR_q^M} = \begin{cases} \hat{\alpha}_q^M + \hat{\beta}_q^M VaR_q^M, if\ \hat{\theta}_{0q} = \hat{\theta}_{1q} = 0 \\ \left(\hat{\alpha}_q^M + \hat{\theta}_{0q}\right) + \left(\hat{\beta}_q^M\right) VaR_q^M, if\ \hat{\theta}_{0q} \neq 0\ and\ \hat{\theta}_{1q} = 0 \\ \left(\hat{\alpha}_q^M\right) + \left(\hat{\beta}_q^M + \hat{\theta}_{1q}\right) VaR_q^M, if\ \hat{\theta}_{0q} = 0\ and\ \hat{\theta}_{1q} \neq 0 \\ \left(\hat{\alpha}_q^M + \hat{\theta}_{0q}\right) + \left(\hat{\beta}_q^M + \hat{\theta}_{1q}\right) VaR_q^M, if\ \hat{\theta}_{0q} \neq 0\ and\ \hat{\theta}_{1q} \neq 0 \end{cases} \tag{6}$$

Using equation (6) we have four cases for stress test before and after the economic crisis: CoVaR did not show statistically significant changes neither the intercept nor the reaction/response parameter (slope); only statistically significant changes on the constant; only on slope coefficient; in both parameters.

Formally, the following expression define the stress test, in which, empirically, it is possible to measure and score the companies' assets that are more negatively affected by the market as a whole in a financial distress scenario, by pointing out the companies that may be more representative in this sense before and after changes on the context economic. Supposing a significant structural change (specifically, on reaction parameter), we would have two risk measures for a given company:

$$\begin{aligned} Before\ Crisis: \Delta CoVaR_b^{i|M} &= \hat{\beta}_q^M \left(VaR_{bq}^M - VaR_{b50\%}^M\right) \\ Afeter\ Crisis: \Delta CoVaR_a^{i|M} &= \left(\hat{\beta}_q^M + \hat{\theta}_{1q}\right)\left(VaR_{aq}^M - VaR_{a50\%}^M\right) \end{aligned} \tag{7}$$

In the case of stress test, the work in question brings two instability measurements to the companies' assets operating in domestic market, including:

- Assessment of how a low returns in the national financial system affects the low companies' returns;
- Analysis of how a change in economic context affects the stress test of companies' asset returns.

These two types of measures allow the scoring of the companies which are most impacted by worst losses in domestic market returns, as well as it is possible to infer the company more directly affected by the changes in context economic.

3 - Database

According to the delimitation of the economic crisis cataloged by NBER described in the following table, we note that the duration of the last economic crisis in the U.S. was December 2007 to June 2009. Assuming the great influence exerted by this country in the global economy, we will develop tests for structural breaks in the equation (7), obtained through the CoVaR methodology. The Table 1 shows the classification of crisis period in U.S., according to National Bureau of Economic Research (NBER).

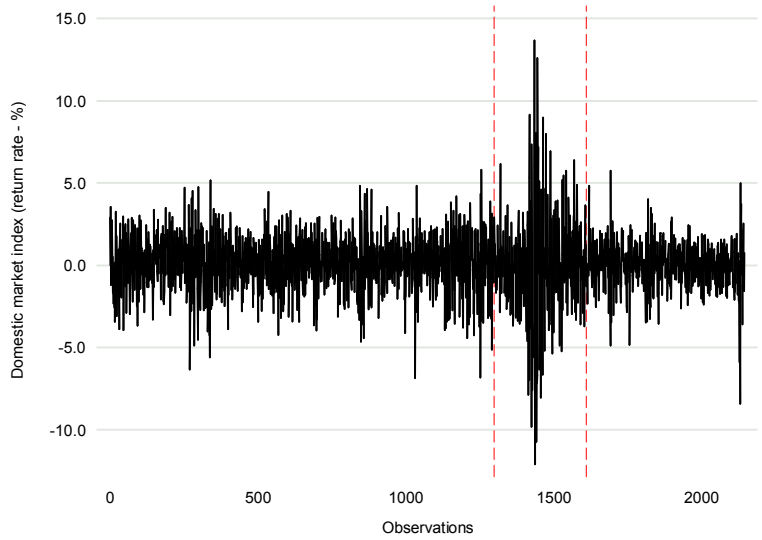
Table 1: NBER Classification of Business cycle in U.S.

Business cycle Reference dates		**Duration in months**			
Peak	**Trough**	**Contraction**	**Expansion**	**Cycle**	
Quarterly dates are in parentheses		*Peak to Trough*	*Previous trough to this peak*	*Trough from Previous Trough*	*Peak from Previous Peak*
	December 1854 (IV)	-	-	-	-
June 1857(II)	December 1858 (IV)	18	30	48	-
October 1860(III)	June 1861 (III)	8	22	30	40
April 1865(I)	December 1867 (I)	32	46	78	54
June 1869(II)	December 1870 (IV)	18	18	36	50
October 1873(III)	March 1879 (I)	65	34	99	52
March 1882(I)	May 1885 (II)	38	36	74	101
March 1887(II)	April 1888 (I)	13	22	35	60
July 1890(III)	May 1891 (II)	10	27	37	40
January 1893(I)	June 1894 (II)	17	20	37	30
December 1895(IV)	June 1897 (II)	18	18	36	35
June 1899(III)	December 1900 (IV)	18	24	42	42
September 1902(IV)	August 1904 (III)	23	21	44	39
May 1907(II)	June 1908 (II)	13	33	46	56
January 1910(I)	January 1912 (IV)	24	19	43	32
January 1913(I)	December 1914 (IV)	23	12	35	36
August 1918(III)	March 1919 (I)	7	44	51	67
January 1920(I)	July 1921 (III)	18	10	28	17
May 1923(II)	July 1924 (III)	14	22	36	40
October 1926(III)	November 1927 (IV)	13	27	40	41
August 1929(III)	March 1933 (I)	43	21	64	34
May 1937(II)	June 1938 (II)	13	50	63	93
February 1945(I)	October 1945 (IV)	8	80	88	93
November 1948(IV)	October 1949 (IV)	11	37	48	45
July 1953(II)	May 1954 (II)	10	45	55	56
August 1957(III)	April 1958 (II)	8	39	47	49
April 1960(II)	February 1961 (I)	10	24	34	32
December 1969(IV)	November 1970 (IV)	11	106	117	116
November 1973(IV)	March 1975 (I)	16	36	52	47
January 1980(I)	July 1980 (III)	6	58	64	74
July 1981(III)	November 1982 (IV)	16	12	28	18
July 1990(III)	March 1991(I)	8	92	100	108
March 2001(I)	November 2001 (IV)	8	120	128	128
December 2007 (IV)	June 2009 (II)	18	73	91	81

Source: NBER: www.nber.org/cycles.html

To avoid possible disruptions caused by the economic crisis between 2007 and 2009, we disregard this period for the stress test calculation. We can see in Figure 1 below that the return rate of Ibovespa had a greater oscillation in the period of American crisis than that recorded the time series. Thus, the structural break test aims to determine the possible consequences of the strong economic contraction in the financial market before and after the crisis period, given the hypothesis of a significant change in reaction coefficient of financial distress in the market return on the asset return of major companies operating in the BM&FBovespa.

Figure 2: Return rate of Ibovespa (domestic market index) between 01/02/2003 and 08/26/2011 – Brazilian financial market



Source: Authors elaboration.
Note: The red dash lines represent the interval of economic crisis in U.S.

For the selection of the companies that took part of this analysis, those that composed Bovespa Index in the first quarter of 2011 (from May to August) were considered. Regardless, another requirement for the participation was the consistent availability of information on daily quotations of the assets in the investigated period. In the Appendix, the Table A1 describes the assets from the participating companies, as well as the descriptive statistics of the returns of those companies and the domestic market index.

The period choice is justified by the fact that follows: after some years of strong economic instability and many monetary reforms, the Brazilian post-1999 inflation has shown more controlled and stable, as well as the national currency has kept the same. The data sample used for the analysis was obtained directly in the system Economatica and it was carried out with 1,756 daily observations on the closing prices of each asset between 01/02/2003 and 08/26/2011.

The sixteen companies considered represent in September 2012 about 50% of the market value of each company in terms of total market value of all companies operating in the BM&FBovespa.

4 – Analysis Results for Brazilian Case

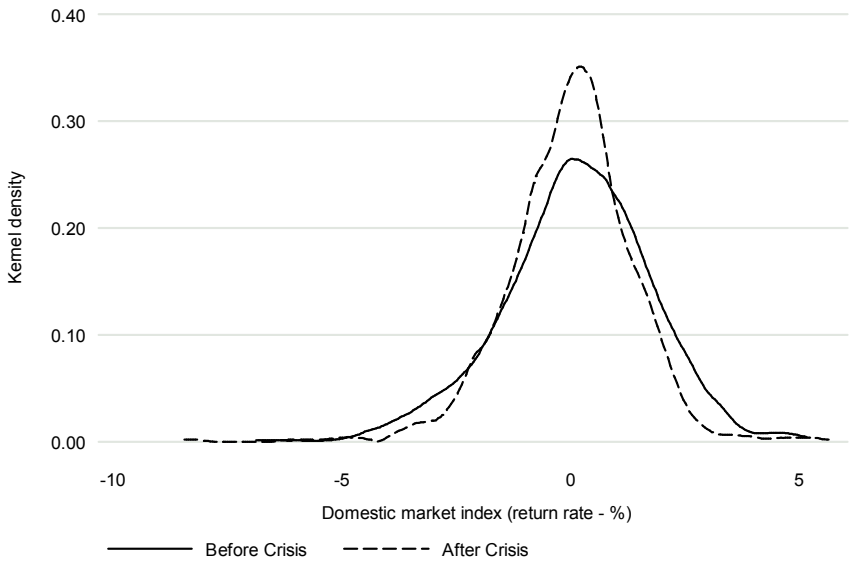
This section presents the results of the stress test, a risk measure, in a context of structural change in the parameters, in which the intention is to identify the companies'

assets operating in BM&FBovespa that are most affected by the return of domestic financial market (Ibovespa) in an environment crisis. Our focus is to study the specific effects on the negative extreme of the distribution, because this region has important information about distress moments of the return series.

The economic crisis that began in late 2007 in the U.S. had a negative impact on the world economy. In Brazil, the effects of the crisis were felt in output growth in the last quarter of 2008 and, especially, in 2009, during which there was a negative real GDP growth of 0.33%. In the Brazilian financial market, the impact occurred faster than the real economy, since mid-2008 the indicator of the domestic market, Ibovespa, had a large increase in the variability of their returns (see Figure 1).

In order to identify possible changes in the Brazilian financial market after this period of international crisis, the Figure 2 shows the distribution of return rate of Ibovespa before and after this period. Remember that this illustration was done disregarding the crisis period itself, due to the objectives of this work that intends to evaluate just the consequences of economic crisis on stress test indicator.

Figure 2: Distribution of return rate of Ibovespa (domestic market index) before and after international economic crisis



Source: Authors elaboration.

As we can see in Figure 2, the distribution of the domestic index returns in both periods have certain differences, highlighting the curve of return after the crisis was relatively flat. This information corroborates the fact that the post-crisis environment, the variability of the return on the domestic market decreased approximately 11%. Furthermore, Figure 2 indicates the existence of possible changes in the tails of the distribution after crisis, especially at the tail end of the negative distribution. With this information, we have a signal of the importance of analyzing the risk measures, such as the stress test, considering a context of structural changes in the parameters.

Table 2 shows the results for the structural change test for the parameters of CoVaR model. This test, based on Qu (2008) and Oka and Qu (2011), was calculated for the percentiles 1, 5 and 10 of all returns of companies' assets in the sample. The null hypothesis of this test admits that there was not change on parameter between the periods.

Table 2: Structural change test for CoVaR parameters (quantiles 0.01, 0.05 and 0.10)

Quantile	Assets	Constant			Slope		
		Before Crisis	After Crisis	Significant change?	Before Crisis	After Crisis	Significant change?
0.01	PETR4	-3.036	-3.0751		0.8799	1.0372	
	PETR3	-3.467	-2.9100	*	0.8279	1.1018	
	LAME4	-4.242	-3.7703		0.5934	1.3627	**
	AMBV4	-3.617	-3.0802		0.7055	0.3563	
	PCAR4	-4.718	-3.5650	*	0.839	0.6312	
	BBAS3	-4.751	-2.6040	***	1.079	1.0288	
	BBDC4	-3.134	-2.2488	**	0.8306	0.8270	
	ITSA4	-3.021	-2.9731		0.8231	1.0221	
	ITUB4	-2.923	-2.7631		0.8147	1.3017	***
	VALE5	-3.744	-2.2030	***	0.5988	1.2642	**
	CSNA3	-3.999	-3.0358	**	1.07	1.1104	
	GGBR4	-3.57	-3.2488		1.054	1.1190	
	USIM5	-3.956	-4.2387		1.257	0.4984	*
	GOAU4	-3.459	-3.3205		0.8915	1.0123	
	VALE3	-4.13	-2.2220	***	0.6601	1.2496	**
	CMIG4	-4.129	-3.2363	**	0.8784	0.6883	
0.05	PETR4	-2.074	-2.0463		0.9384	0.9432	
	PETR3	-2.288	-2.1034		0.8881	0.9770	
	LAME4	-3.001	-2.4348	***	0.6553	1.0808	***
	AMBV4	-2.288	-1.9980		0.5624	0.4919	
	PCAR4	-3.076	-2.4918	***	0.7069	0.6416	
	BBAS3	-2.865	-1.9752	***	1.001	0.8982	
	BBDC4	-2.112	-1.4766	***	0.8812	0.9918	
	ITSA4	-2.154	-1.6438	***	0.836	1.0344	**
	ITUB4	-2.183	-1.7242	***	0.8094	1.0553	***
	VALE5	-2.625	-1.4120	***	0.6756	1.0570	***
	CSNA3	-2.65	-1.8384	***	0.9679	1.1796	*
	GGBR4	-2.36	-2.0041	*	0.9687	1.1185	
	USIM5	-2.822	-2.6007		1.238	0.9631	*
	GOAU4	-2.25	-2.2640		0.9584	1.1613	**
	VALE3	-2.829	-1.6000	***	0.6677	1.0400	***
	CMIG4	-2.602	-2.0584	**	0.9491	0.5890	**
0.10	PETR4	-1.603	-1.3971	*	0.8919	0.9667	
	PETR3	-1.734	-1.5585		0.8616	0.8954	
	LAME4	-2.173	-1.9418		0.6296	0.9733	***
	AMBV4	-1.761	-1.4059	***	0.4932	0.5325	
	PCAR4	-2.308	-1.6500	***	0.6631	0.6043	
	BBAS3	-2.117	-1.5063	***	0.9711	1.0359	
	BBDC4	-1.599	-1.1277	***	0.8415	1.0260	***
	ITSA4	-1.662	-1.2872	***	0.8602	1.0451	**
	ITUB4	-1.701	-1.3081	***	0.8117	1.0574	***
	VALE5	-1.926	-1.0649	***	0.725	1.1461	***
	CSNA3	-1.985	-1.5145	***	1.019	1.0725	
	GGBR4	-1.868	-1.6053	*	0.9814	1.1858	**
	USIM5	-2.157	-2.0353		1.274	1.0696	**
	GOAU4	-1.793	-1.8433		0.9412	1.0750	
	VALE3	-2.02	-1.1151	***	0.7134	1.0781	***
	CMIG4	-2.062	-1.6387	***	0.9633	0.6352	***
N	1,756	1,221	535	-	1,221	535	-

Legend: * p<.1; ** p<.05; *** p<.01

Source: Authors Elaboration.

Note: the significant column represents the indications about structural change test, based in Qu (2008) and Oka and Qu (2011).

In general, we find that the parameters (constant and slope) of CoVaR model had statistically significant changes, regardless of the quantile evaluated. For example,

for the quantile 0.05 and assuming a significance level of 10%, we observed that 69% of companies' assets had alterations in at least one of the parameters. In the specific case of the reaction coefficient (slope), decisive parameter for the calculation of the marginal contribution of a distress in the market index on the firms' returns, we find that most companies (56%) had changes in this parameter. The slope parameter, according to Adrian and Brunnermeier (2011), measures the response of the VaR returns of asset firm i given the VaR returns of market.

Analyzing the coefficients of reaction between the two periods were statistically significant changes, we point out that in general compute the value at risk of the returns of firms became more sensitive to the value at risk of the Bovespa index returns. This result is observed in the three quantiles. The stocks with the highest variation were LAME4, VALE5 and VALE3, indicating that a distress on the market return is generating a greater effect on the value at risk of the firm. In the case of Americana stores (LAME4), we have some recent events that may have contributed to the sensitivity of their stocks to market fluctuations; an example was the bankruptcy filing made by Athenabanco Fomento Mercantil in the period after crisis. We also note that some firms had a negative change in response coefficient, like USIM5 and CMIG4 that showed consistently for the three quantile definitions less sensitive to the value at risk IBOV after economic crisis.

Another interesting result is that most of the companies' assets post-crisis had a response coefficient of greater than one unit, indicating that a financial distress on the market index affected more than proportionally the value at risk of each firm. This reflects a clear sign of financial instability environment created during the economic crisis 2007-2009.

Table 3 shows the stress test estimated for each financial paper traded in the domestic capital market of the sample, compared to a distress indicator in the domestic market, IBOV. More specifically, to assess the marginal contribution of a financial distress in the domestic market index on the vulnerability of the return of firm i.

Table 3: Stress test for returns of companies' assets before and after economic crisis 2007-2009

Sector		Before Crisis (B)			After Crisis (A)		
	Assets	Quantile 0.01	Quantile 0.05	Quantile 0.10	Quantile 0.01	Quantile 0.05	Quantile 0.10
Oil, Gas and Biofuel	**PETR4#**	-3.722	-2.751	-1.903	-3.226	-2.119	-1.601
	PETR3	-3.502	-2.604	-1.838	-3.035	-2.006	-1.547
Cyclical consumption	**LAME4#**	-2.510	-1.921	-1.343	-4.996	-2.441	-1.747
Non-cyclical consumption	**AMBV4#**	-2.984	-1.649	-1.052	-2.587	-1.270	-0.885
	PCAR4#	-3.549	-2.072	-1.415	-3.076	-1.596	-1.190
Financial	**BBAS3**	-4.565	-2.935	-2.072	-3.957	-2.260	-1.743
	BBDC4#	-3.513	-2.583	-1.795	-3.045	-1.990	-1.842
	ITSA4#	-3.482	-2.451	-1.835	-3.018	-2.336	-1.876
	ITUB4#	-3.446	-2.373	-1.732	-4.773	-2.383	-1.898
Basic Material	**VALE5#**	-2.533	-1.981	-1.547	-4.635	-2.387	-2.057
	CSNA3	-4.528	-2.838	-2.174	-3.925	-2.664	-1.829
	GGBR4#	-4.458	-2.840	-2.094	-3.864	-2.188	-2.129
	USIM5#	-5.319	-3.629	-2.719	-1.829	-2.175	-1.920
	GOAU4#	-3.771	-2.810	-2.008	-3.269	-2.623	-1.689
	VALE3	-2.792	-1.958	-1.522	-4.581	-2.348	-1.935
Public Utility	**CMIG4#**	-3.716	-2.783	-2.055	-3.221	-1.330	-1.140

Source: Authors Elaboration.
Note: the asset with symbol # means preferred stocks; the asset without symbol represents common stocks.

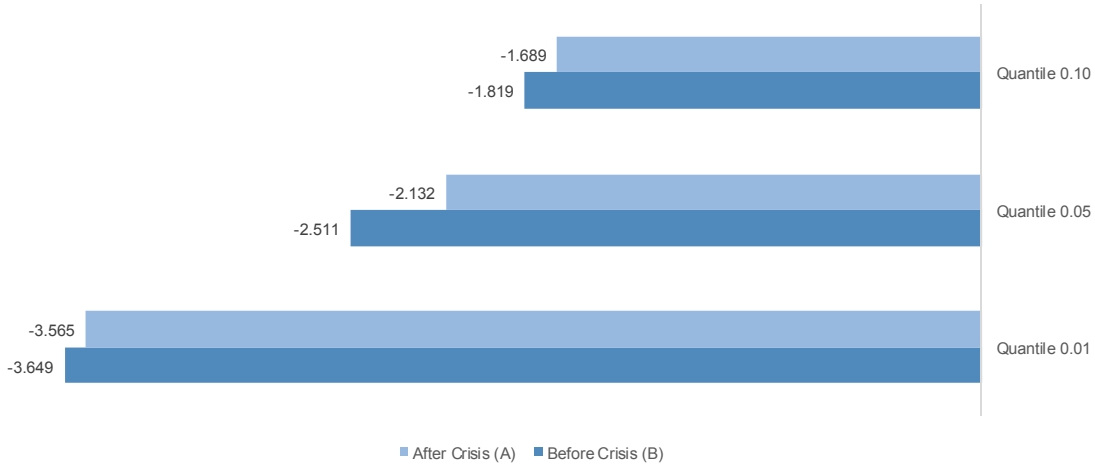
We can check in Table 3, initially, some consistency in the ordering of the stress test measure to each asset of the data, mainly before the crisis, independent of the quantile evaluated. The assets with higher stress effect caused by the market are: USIM5, BBAS3, CSNA3, GGBR4. Those information indicate that, in particular, assets of companies related to the basic materials sector were more susceptible to financial distress in the market index.

In general, the ranking of the stress test after crisis indicate that the assets more sensitive to a distress market are as follows: VALE5, ITUB4 and CSNA3. We can see the CSNA3 asset remained one of the most that value at risk of IBOV (in adverse context) affected the value at risk of the return of this firm.

When we verify the measures of stress tests post-crisis, we found that the ordering of assets becomes more unstable to the definition of quantile risk. For example, the return on assets of LAME4 was with greater stress for the first quantile, the third to the quantile 0.05 and ninth for the last quantile. This fact occurred due to the response coefficient that showed more sensibility to lower quantiles, where in the quantile 0.01 the response coefficient was 1.36, while in the other quantiles this parameter decreased strongly, respectively, 1.08 for the quantile 0.05 and 0.97 for the quantile 0.10. A variation of about 30% in the response coefficient between quantiles 0.10 and 0.01, reflecting directly in the ranking of the stress test.

The Figure 3 exhibits the average of stress test for returns of companies' assets in Brazilian Financial Market before and after crisis for different quantiles.

Figure 3: Average of Stress test for returns of companies' assets in Brazilian Financial Market

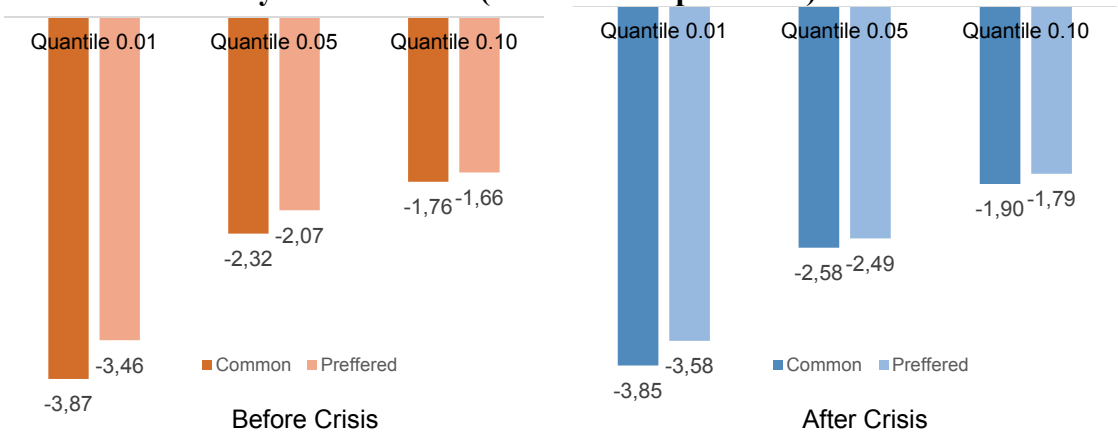


Source: Authors Elaboration.

The results of Figure 3 reinforce the idea that after the period of the American crisis the risk measure investigated in this study for Brazilian firms were impacted by adverse macroeconomic scenario. However, we note that, on average, the returns of firms were less stressed to changes in the value at risk of the domestic market, regardless of the definition of quantile risk. For the quantile 0.05, we observed a statistically significant difference over 15% in this indicator between before and after crisis, meaning a reduction of the marginal contribution of the value at risk of IBOV to the firms operating in the domestic market.

These results in reduction of the stress test after crisis remains also when considering the various types of assets (see Figure 4).

Figure 4: Average of Stress test for returns of companies' assets in Brazilian Financial Market by kind of stocks (common and preferred)



Source: Authors Elaboration.

In Figure 4, we see that for both common and preferred assets had reduced stress indicator after crisis. Thus, we highlight that firms operating in the Brazilian financial

market had, in general, a reduction in the stress test, independently of the quantile of risk and the type of stock (common or preferred), signaling the importance of calculating this indicator with structural changes.

5 - Conclusions

The main innovation of this work was to discuss through the construction of stress test with structural changes, the losses responses of each asset before and after economic crisis 2007-2009 in response to the returns of domestic market (IBOV), given by a financial distress in the returns of IBOV. The central results show that some of the reaction coefficient of the returns of firms operating in the Brazilian financial market had structural changes, as well as the value at risk of the market index decreased between the two periods. In general, the marginal contribution of financial distress in the market index, independently of the quantile evaluated, generated a lower stress on the returns of firms after the international crisis than before of this adverse macroeconomic context.

Therefore, the results of this study reinforce the importance of using risk indicators sensitive to potential changes, for example, in the economic or political context. As noted, the U.S. economic crisis of 2007-2009, cataloged by NBER, reduced indicators of stress in Brazil investigated period (until 2011), indicating a relative strengthening of the domestic financial market. When we do not consider structural changes in the parameters of risk measures, such as the works of Almeida, Frascaroli and Cunha (2012) and Araújo and Leão (2012) applying the methodology CoVaR to Brazil, we can under or overestimate the indicators.

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Appendix

Table A1: Descriptive statistics of returns of the companies selected and market index from January 2003 to August 2011

		Total					Before Crisis					After Crisis				
Description	**Variable**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Return of Ibovespa (market index)	**IBOV**	1756	0.1001	1.5626	-8.4307	5.7458	1221	0.1410	1.6320	-6.8565	5.1589	535	0.0067	1.3881	-8.4307	5.7458
Return of preferred shares from Petrobrás	**PETR4**	1756	0.0957	1.8783	-7.8846	13.2463	1221	0.1708	1.9441	-6.8858	13.2463	535	-0.0758	1.7079	-7.8846	5.1790
Return of common shares from Petrobrás	**PETR3**	1756	0.0887	1.9357	-8.2302	13.4972	1221	0.1715	2.0024	-7.4662	13.4972	535	-0.1001	1.7612	-8.2302	5.4583
Return of preferred shares from Lojas Americanas	**LAME4**	1756	0.2043	2.2865	-8.6178	9.2288	1221	0.2563	2.3306	-8.6178	9.0151	535	0.0858	2.1801	-6.6569	9.2288
Return of preferred shares from AMBEV*	**AMBV4**	1756	0.1171	1.6848	-16.2071	6.0027	1221	0.1019	1.7608	-16.2071	6.0027	535	0.1519	1.4982	-4.7602	5.7433
Return of preferred shares from Pão de Açúcar	**PCAR4**	1756	0.0340	2.0419	-8.0592	11.9030	1221	0.0115	2.1335	-7.8605	8.7112	535	0.0853	1.8167	-8.0592	11.9030
Return of common shares from Banco do Brasil	**BBAS3**	1756	0.1633	2.2990	-9.0560	14.3303	1221	0.2092	2.4815	-9.0560	14.3303	535	0.0586	1.8130	-7.1204	7.2921
Return of preferred shares from Bradesco	**BBDC4**	1756	0.1290	1.9372	-9.2210	8.4342	1221	0.1716	2.0374	-7.0388	8.4342	535	0.0319	1.6841	-9.2210	5.6333
Return of preferred shares from Itaú (S.A.)	**ITSA4**	1756	0.1352	1.9402	-11.5907	7.6283	1221	0.1863	1.9832	-5.5994	7.6283	535	0.0188	1.8346	-11.5907	6.4162
Return of preferred shares from Itaú-Unibanco	**ITUB4**	1756	0.1107	1.9593	-10.2225	7.9385	1221	0.1572	2.0127	-5.9983	7.9385	535	0.0046	1.8292	-10.2225	6.6249
Return of preferred shares from Vale do Rio Doce	**VALE5**	1756	0.1352	2.0065	-9.6205	8.2377	1221	0.1663	2.0781	-8.2618	7.4435	535	0.0641	1.8325	-9.6205	8.2377
Return of common shares from Cia. Sid.Nacional	**CSNA3**	1756	0.1492	2.3446	-12.4014	8.6328	1221	0.2398	2.4875	-9.1044	8.6328	535	-0.0576	1.9668	-12.4014	8.1068
Return of preferred shares from Gerdau (S.A.)	**GGBR4**	1756	0.1166	2.3157	-11.6154	9.8495	1221	0.2010	2.3350	-11.6154	8.3844	535	-0.0759	2.2612	-11.4337	9.8495
Return of preferred shares from Usiminas	**USIM5**	1756	0.1641	2.7014	-13.6324	12.3593	1221	0.2754	2.8349	-13.6324	9.6228	535	-0.0898	2.3518	-6.6656	12.3593
Return of preferred shares from Gerdau	**GOAU4**	1756	0.1361	2.2294	-9.5714	9.4811	1221	0.2286	2.2084	-9.5714	8.9612	535	-0.0750	2.2647	-8.6146	9.4811
Return of common shares from Vale do Rio Doce	**VALE3**	1756	0.1381	2.0869	-10.0072	8.5019	1221	0.1755	2.1666	-8.6561	7.3489	535	0.0529	1.8916	-10.0072	8.5019
Return of preferred shares from CEMIG**	**CMIG4**	1756	0.1202	2.1834	-7.9631	10.0889	1221	0.1467	2.4149	-7.9631	10.0889	535	0.0597	1.5293	-7.0242	4.7667

Source: Authors elaboration from database of Economatica.

**AMBEV= Beverages Company of the Americas; **CEMIG= Energy Company of Minas Gerais*