UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
FACULDADE DE CIÊNCIAS ECONÔMICAS
DEPARTAMENTO DE ECONOMIA E RELAÇÕES INTERNACIONAIS

LUCAS KONIKIEWEZ MATUKAIT

THE IMPACT OF DERIVATIVES USAGE ON FIRM VALUE: EVIDENCES FROM BRAZIL

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ABSTRACT

This paper examines the use of derivatives and their impact on firm value for a sample of Brazilian non-financial companies listed on the Sao Paulo stock exchange from 2003 to 2015. Using the Tobin Q index as an approximation of the value of the firm, the model is regressed on a parametric methodology: Pooled OLS, Fixed Effects and Random Effects. And also a semi-parametric methodology, Generalized Estimating Equations (GEE). Regardless of the methodology used, the use of derivatives does not have a significant impact on the companies' market value, corroborating with the theory of irrelevance of the risk management policy developed by Modigliani and Miller (1958).

Keywords: Derivatives. market value. Tobin's Q. hedging.

O impacto do uso de derivativos sobre o valor das firmas: evidências para o Brasil

RESUMO

Este artigo examina o uso de derivativos e seu impacto no valor firme das empresas não financeiras listadas na bolsa de valores de São Paulo de 2003 a 2015. Usando o índice Q de Tobin como *proxy* para o valor da empresa, o modelo é regredido através de uma metodologia paramétrica: *Pooled OLS*, efeitos fixos e efeitos aleatórios. E também uma metodologia semi-paramétrica, Equações de Estimativa Generalizada (GEE). Independentemente da metodologia utilizada, o uso de derivados não tem um impacto estatisticamente significativo no valor de mercado das empresas, corroborando a teoria da irrelevância da política de gerenciamento de risco desenvolvida por Modigliani e Miller (1958).

Palavras-chave: Derivativos, valor de mercado, Q de Tobin, Hedge.

LIST OF FIGURES

LIST OF TABLES

CONTENTS

1 INTRODUCTION

It is denominated hedge the operation by which the company seeks protection against the risk of price fluctuations of one or more assets. In this way, hedge promotes a kind of insurance against price fluctuations that could influence the company's performance observed in its net profit and cash flow. Hedge strategies can assume innumerable forms, and can be elaborated either through financial instruments or through mechanisms related to the operational features of the firms. In this paper we focus on hedge strategies based on derivative instruments, and we seek to investigate their impact on the market value of the companies that use them.

The derivatives market has been growing rapidly, since the 1980s (CHUI, 2012). The development of pricing models, technological advancement and greater integration of financial markets are reasons mentioned as possible causes of this expansion. Although the data show the rapidity of such evolution, the corporate finance literature consensus has not yet been reached if the use of derivatives adds value to the firm. If the hypotheses of Modigliani and Miller (1958) are valid, the firm's financial policy will have no impact whatsoever on its value. The authors show that, with a fixed investment, in a frictionless environment, the company's financial policy is irrelevant.

Some authors like DeMarzo and Duffie (1995), Smith and Stulz (1985), Froot, Scharfstein and Stein (1992) and Leland (1998) argue that capital market imperfections can make it so that the companies that use derivatives to hedge are valued with a premium by the investors. For instance, by reducing expected taxes and financial distress costs, mitigating underinvestment and increasing debt capacity to take advantage of debt tax-shields.

These conflicting theories are reflected in conflicting empirical results, which show divergences with respect to the impact of the use of currency derivatives on firm value. In the United States case, Allayannis and Weston (2001) found a positive relation and a hedging premium of nearly 5% for the firms that use currency derivatives. However, Jin and Jorion (2006), studying the same country, but limiting the study to firms in the oil and gas sector, showed a negative and statistically non-significant relation between the use of commodity derivatives and firm value.

In the case of Brazil, Rossi (2008) assessed the impact of the use of derivatives on the value of the firm with a sample of 175 Brazilian non-financial companies listed on Bovespa and found results positive and significant in their study. Serafini (2009), however, using a sample of 48 Brazilian non-financial companies that compose the Bovespa index, found a statistically insignificant relation between the use of exchange derivatives and the market value of companies.

In this paper we seek to estimate the impact of the use of derivatives on the market value of non-financial Brazilian companies during the period from 2003 to 2015. To do so, we initially followed the methodology used in the studies mentioned above, through estimation via Panel Linear Models: Pooled OLS, Fixed Effects and Random Effects. Subsequently, as a way of dealing with the clustered nature of the data, the estimation was done via Generalized Estimating Equations (GEE). The results show that, by controlling for several characteristics of firms, the use of derivatives does not have a statistically significant impact on the market value of Brazilian companies.

The paper is organized as follows: Section 2 gives a brief presentation of the Brazilian National Financial System; Section 3 reviews the theoretical literature and summarizes the results of some of the empirical work in the area; Section 4 gives a description of the data collection and estimation methods used; Section 5 presents the results and discusses them based on the literature; Section 6 concludes the study.

2 THE BRAZILIAN FINANCIAL SYSTEM

The Brazilian National Financial System (SFN) was instituted, structured and regulated by Law 4.595/64, which was received by the Federal Constitution of 1988.

The SFN is structured and dismembered into two subsystems: regulatory and operating system. The regulatory subsystem consists of institutions that establish guidelines for the operation of financial institutions. The subsystem composed, amongst others, by the National Monetary Council (CMN), the Central Bank of Brazil, the Securities and Exchange Commission (CVM).

The CMN, which was established by Law 4.595, December 31, 1964, is the body responsible for issuing general guidelines for the functioning of the SFN and be the maker of monetary and exchange rate policies. The CMN is composed of the Minister of Finance (Chairman of the Board), the Minister of Planning, Budget and Management and the President of the Central Bank of Brazil.

The Central Bank of Brazil is a federal autarchy linked to the Ministry of Finance, and was also created by Law 4.595, dated December 31, 1964. It is the main executor of the CMN guidelines and responsible for guaranteeing the purchasing power of the national currency.

Also a federal autarchy linked to the Ministry of Finance is The Brazilian Securities and Exchange Commission (CVM). The CVM is responsible for regulating, developing, controlling and supervising the financial markets. It's main purpose is to ensure the efficient and regular operation of the stock, derivative and over-the-counter markets.

The BM&F BOVESPA is the main stock exchange in Brazil. It is the place where securities are traded, both in the spot market and in futures, forward, options and swap markets. It performs the registration, compensation and settlement, physical or financial, of operations with securities and contracts held on the floor or on an electronic system.

The derivative contracts traded on the BM&F BOVESPA are classified into the following types:

- Forward: Involve obligations to purchase and sell assets in the future and may or may not be standardized contracts;
- Future: Have the same structure as forward contracts, but are traded exclusively on the stock exchange through standardized contracts, with daily adjustments to adjust for price changes;
- Option: Involve rights to buy and sell contracts in the future, for which a premium

is paid. The payer of the premium owns the rights in the operation and is called the holder, and whoever receives the premium has the obligation to buy or sell the product in the future and is called the writer of the operation;

- Swap: Consists of an agreement for two parties to change the risk of an active or passive position, at a future date, according to pre-established criteria.

3 DERIVATIVES AND FIRM VALUE

Modigliani and Miller (1958) show that under the hypotheses of non-existence of taxes, transaction costs and bankruptcy costs, the choice of a company's financing policy is irrelevant. Therefore, the firm's market value is independent of the risk management policy adopted. Their argument is that investors themselves can manage the risk they are exposed to by diversifying their portfolios, hence the corporate risk management policy is irrelevant to the investors decision making.

If that theory is correct, in order for a company's hedging policy to have an impact on its market value, this must happen due to elements not incorporated in what was later known as the Modigliani-Miller Theorem. That is, via impacts on taxes paid, transaction costs or on the firm's investment decisions.

Based on the Modigliani and Miller model, and relaxing some of its hypotheses, several authors have tried to argue that the use of hedge strategies can be determinant of the market value of a company. DeMarzo and Duffie (1995) argue that even if investors could control their own risk exposures via portfolio diversification, hedging policies could be used as a signaling tool by the firm. The reason for the informational effect is that managerial quality is difficult to determine for outsiders. A less volatile cash flow may signal a greater ability of the manager and therefore affect the investor's decision-making.

Smith and Stulz (1985) show that, given a convex tax structure or the existence of financial distress costs, investors may benefit from the reduction in the volatility of a company's cash flow obtained through a hedging policy. According to them, in a progressive tax system, hedging can reduce the expected tax payment of the firm, increasing its net profit, which in turn has positive effects on the firm's market value. In addition, the authors also show that in case of the existence of bankruptcy costs, hedging would reduce the chance of the company in question having to pay these costs, reducing the variability of its future value. Which should make investors better evaluate the company with a hedging policy, increasing its market value.

According to Froot, Scharfstein and Stein (1992), hedging help companies mitigate their underinvestment problem by ensuring available internal funds when needed, alleviating the problems associated with costly external financing. In their model, financial market imperfections make the cost of capital of the company proportional to its cash flow volatility. Therefore, without risk management policies, firms are sometimes forced to perform suboptimal investments. Hedging would then be a way for the company to reduce fluctuations in its cash flow, which in turn would reduce its cost of capital, allowing it to make better investments and increasing its market value.

Leland (1998) finds that hedging increases the firm's debt capacity, allowing the firm to increase its leverage. Increased leverage can then increase its earnings after taxes, since interest expenses are deductible in many tax schemes. Hence the taxes can be lowered by increasing interest expenses, leaving more money for shareholders and bondholders to divide between themselves, which should have a positive effect on the firm's market value.

The existence of empirical studies on the impact of the use of derivatives on firm value was delayed due to the fact that until the 1990s information on risk management, more specifically hedging activities, was considered important strategic secrets by companies, therefore not being disclosed. The lack of information meant that few studies were carried out in the area, and the few made were through survey data. Nance, Smith and Smithson (1993) used data from a survey on the use of derivatives by Fortune 500 companies and found that hedging companies have more convex tax functions, are larger, and have more growth opportunities.

From the 2000s onwards, the disclosure of information on the use of derivatives by companies in their annual reports allowed for more statistically relevant empirical studies. Allayannis and Weston (2001) sought to test empirically the relationship between the use of derivatives and the firm's Market value using real data on the use of derivatives by 720 firms that were exposed to exchange rate risk between 1990 and 1995 via exports and imports. The results presented by the authors confirm the existence of a positive and statistically significant relationship between the use of currency derivatives and the value of the firm. The authors found that, on average, companies with foreign exchange risk using derivatives are worth 4.87% more than firms that do not use them.

Jin and Jorion (2006) apply the Allayannis and Weston methodology in a sample of 119 American oil and gas companies between 1998 and 2001. The results found by the authors, however, indicate that there is no significant difference between the values of firms that use derivatives and the values of firms that do not use them, unlike the results found by Allayannis and Weston.

As for the Brazilian case, Rossi (2008) test the same impact on a sample of Brazilian non-financial companies listed on the São Paulo stock exchange, from 1996 to 2006, finding evidence of a hedge premium of up to 10% on the firm's market value.

4 DATA AND METHODS

The sample is composed of all the non-financial companies traded on BM&F Bovespa during the period from January 2003 to December 2015 with no missing market value data in the Economática database. Financial firms are excluded from the sample in view of the fact that they are, to a large extent, market-makers in the derivatives market and have different goals in the use of derivatives than those of non-financial companies. The choice of the analysis period was due to the availability of data at the time of collection. Despite the possibility of creating a survival bias, we chose to include in the sample only companies traded during the whole period to have a balanced panel and based on the methodology of Allayannis and Weston (2001), Jin and Jorion (2006) and Rossi (2008). The sample is composed of 100 companies over 13 years, or 1300 company-year observations.

4.1 Use of Derivatives

Data on the use of derivatives by the companies were obtained directly from the explanatory notes of their annual reports. The Brazilian Securities and Exchange Commission (CVM) obliges all public companies that use derivative contracts to disclose them in an explanatory note appended to its financial statements and the quarterly information. In this way, the companies that informed using derivatives in their annual report were considered as derivatives users.

Based on these data, a dummy variable is constructed, assuming a value of 1, if the company used some type of derivative contract during that year and 0 otherwise. In addition, in order to test the impact of the complexity of the strategies used by the companies, a second variable was constructed that assumes the following values, based on the complexity of the contracts used:

- 0, if the company did not use derivative contracts in year i;
- 1, if the company used forward contracts in year i;
- 2, if the company used futures contracts in year i;
- 3, if the company used call or put options in year i;
- 4, if the company used swap contracts in year i;
- if the company has used more than one type of contract in year i, add the individual weights of each contract used;

Table 4.1: Use of derivatives by the companies

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of Firms	100	100	100	100	100	100	100	100	100	100	100	100	100
Users	41	42	45	46	47	50	47	51	50	54	52	56	54
Nonusers	59	58	55	54	53	50	53	49	50	46	48	44	46
Number of users by type of contract													
Forward	4	6	5	7	10	21	21	26	30	27	28	30	33
Future	5	5	5	7	8	9	8	9	6	7	7	8	8
Option	7	6	8	8	8	7	6	8	8	7	7	7	8
Swap	41	42	45	44	41	38	38	39	36	43	41	42	40

Source: Prepared by the author.

Table 1 shows the evolution over time of the use of derivatives by the companies. There is an upward trend of the number of companies that use derivatives during the period. In 2003, 41 of the 100 companies in our sample used some type of derivative contract, in 2015 that figure was 54. This trend of increase was only interrupted in 2009, when large losses incurred by Brazilian companies with interest and foreign exchange derivatives were reported. These companies were betting on the continuity of the exchange rate appreciation and the fall in interest rates, and saw their contracts lose value quickly in the face of the rapid rise in interest rates and exchange rate devaluation that occurred in the period due to the global financial crisis of 2008. (FILHO; PAULA, 2012)

As for the type of contract, as in Rossi (2007), the contract most used by Brazilian companies is swap, being used by between 36 and 45 companies of the sample during the analyzed period. Also noteworthy was the large increase in the number of users of forward contracts, from 4 in 2003 to 33 in 2015. Future and Options are only marginally used, and its number of users is more or less stable during the 13 years.

4.2 Market Value

As a proxy for the market value of the companies, the Tobin's Q was used (TOBIN, 1969). It is defined as the ratio of the firm's market value to the replacement cost of the assets. As in Allayannis, Lel and Miller (2012), Allayannis and Weston (2001) and Rossi (2008), the formula for calculating Tobin's Q was as follows:

$$Q = \frac{BVA - BVE + MVE}{BVA} \tag{4.1}$$

Where BVA represents the book value of the company's total assets, BVE represents the book value of the company's equity and MVE represents the market value of the company's equity. The data needed to calculate Tobin's Q were obtained from the Economática database and directly from the companies' annual balance sheets. The market value of shareholders' equity was calculated by multiplying the total number of each of the company's outstanding shares traded during the year by their respective annual closing prices.

4.3 Control Variables

Given that the values of Tobin's Q can be affected by several factors, it is necessary to isolate the effect of the use of derivatives by including variables that, according to the literature, can have an impact on the market value of the companies. The following control variables were included in the model:

- Size: Empirical work on the effect of firm size on its market value is still inconclusive. However, firm size is a factor commonly used to characterize firms, and can be strongly related with the firm value, as shown in Allayannis and Weston (2001) and Rossi (2008). The proxy used to measure the size of the companies was the log of its total assets.
- Liquidity: According to Jensen (1986), the probability of investing in projects with lower return on investment tends to increase when companies have more cash. Thus, a negative relationship between liquidity and Tobin's Q is expected. The proxy used was the current liquidity index, defined as the ratio of current assets to current liabilities.
- Leverage: The value of a company may be related to its capital structure. If there are tax shields with respect to interest payments, as described in Smith and Stulz (1985) and Leland (1998), the impact will be positive. If the increase in leverage represents an increase in the probability of incurring bankruptcy costs, its impact will be negative. The company's leverage was measured as the ratio of long-term debt to total assets.
- Profitability: More profitable companies are expected to have a higher market value than less profitable ones. Return on Assets (ROA), defined as the ratio of net income to total assets, is used to measure the company's profitability.

Table 4.2: Summary Statistics - Control Variables and Tobin's Q

Statistic	Min	Pctl(25)	Mean	Pctl(75)	Max	Median	St. Dev.
Tobin	0.356	0.906	1.470	1.710	13.600	1.190	0.962
Size	15.400	19.900	21.400	22.900	27.500	21.300	2.050
Liquidity	0.014	0.926	1.710	1.980	48.900	1.320	2.270
ROA	−2.840	0.020	0.054	0.122	0.908	0.070	0.186
Leverage	0.003	0.473	0.723	0.786	5.630	0.608	0.553

Source: Prepared by the author.

Table 4.2 presents the summary statistics for the control variables and for the variable referring to Tobin's Q. The Tobin's Q variable presents an average of 1,470, with a standard deviation of 0.962, showing a great variability in the sample. In addition, the Q of Tobin has a mean higher than its median, revealing an asymmetry in its distribution. Similar fact was observed by Allayannis and Weston (2001), Jin and Jorion (2006) and Rossi (2008). To correct it, we use the logarithm of Tobin's Q as the dependent variable for the estimations. The firms in the sample have a mean logarithm of assets of 21.4, with a standard deviation of 2.05, indicating that the sample is not confined to large companies, there are also medium and small companies when compared to the average. The other variables also indicate that the control variables have sufficient variability to control the differences between firms.

4.4 Interaction Variables

In order to identify the effects of the macroeconomic scenario on the impact of the use of derivatives, three interaction variables are constructed between the use of derivatives and the annual returns of three of the main variables against which companies seek hedge: Interest rate, exchange rate and stock market movements as measured by the Bovespa Index. In the following sections a brief discussion of the behavior of these variables during the analyzed period is made.

4.4.1 Interest Rate - CDI

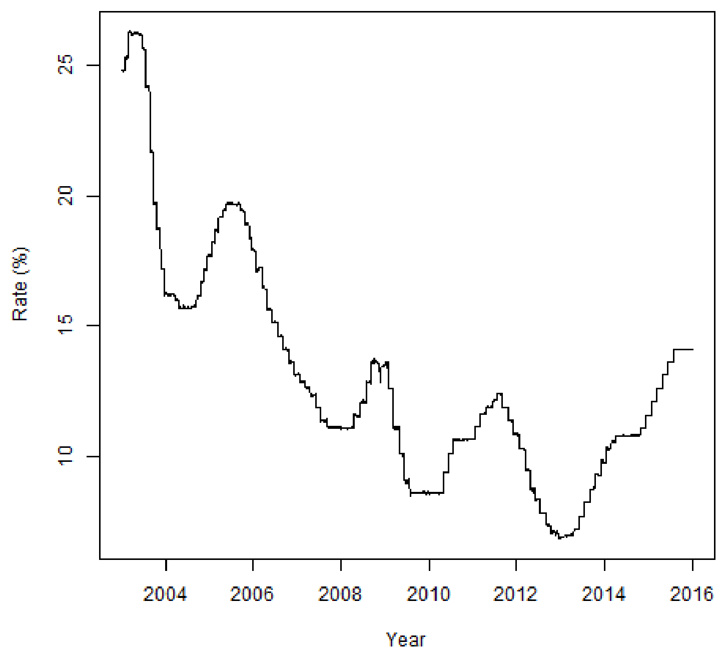
We collect the Interbank Deposit Rate (CDI) time series from the Brazil's Central Bank Time Series Management System at 10/21/2016. The daily separated series started in 01/02/2003 and ended in 12/31/2015, totaling 3247 observations. The Figure 4.1 shows the series through the period.

Table 4.3: Descriptive Statistics - CDI

Mean	Minimum	Maximum	SD	Skewness	Kurtosis
13.0705	6.84	26.32	4.4119	1.1369	4.1130

Source: Prepared by the author.

Figure 4.1: Interbank Deposit Rate (CDI) 2003-2015



Data source: BCB – Time Series Management System.

The high interest rates from the beginning of the period can be explained, in part, by the election of Luiz Inácio Lula da Silva, from the opposition Workers Party in 2002, which seems to have provoked an instability in the financial market in agreement with the one proposed by Mei and Guo (2004) and the recent evidence for Brazil presented in Marques and Santos (2016).

Between 2003 and 2013, however, the series shows a clear downward trend. This trend can be explained by the great decrease in the country risk, measured by the Brazilian Emerging Markets Bond Index Plus (EMBI+), which went from 1387 points in 02/01/2003 to 224 points by the end of 2013. This, added to the exchange rate appreciation observed during the period allowed the easing of the monetary policy used in the Inflation Targeting Regime.

This downward trend is interrupted in three periods. The first one is between September 2004 and September 2005, when the CDI went from 15.73% to 19.64%. The increase came in response to market pessimism regarding inflation in the face of a fast-growing economy (Copom, 2004). The second period of interruption of the interest rate drop is between May 2008 and February 2009, peak period of the global financial crisis, when the interest rate went from 11.18% to 13.67%. The third interruption period was between April 2010 and September 2011, increasing from 8.59% to 12.45%. The justification presented for this increase was the containment of inflationary pressures resulting from the strong economic growth presented during the period, which reached 2.7% in the first quarter of 2010 (Copom, 2010).

As of April 2013, however, there is a reversal of the downward trend in interest rates. This can be explained by the need to contain the inflationary pressures generated by the change in conduction of the macroeconomic policy during the Dilma Rousseff government (2011-2015), which promoted an increase in public spending from 16.8% of GDP in 2011 To 19.6% in 2015. Forcing the central bank to raise the interest rate in order to contain the inflationary pressures.

To test the existence of a unit root, we use the Augmented Dickey-Fuller (ADF) test (DICKEY; FULLER, 1979), not rejecting the null hypothesis of presence of unit root at a significance level of 5%. And to test the stationarity of the series we use the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test (KWIATKOWSKI et al., 1992), which rejected the null hypothesis of stationarity at the significance level of 5%. The statistics generated, as well as their corresponding p-values are shown in the Table 4.4 .

Table 4.4: Tests - CDI

	Estimate	p-value
ADF	-0.9392	0.9486
KPSS	13.912	0.01

Source: Prepared by the author.

4.4.2 Ibovespa

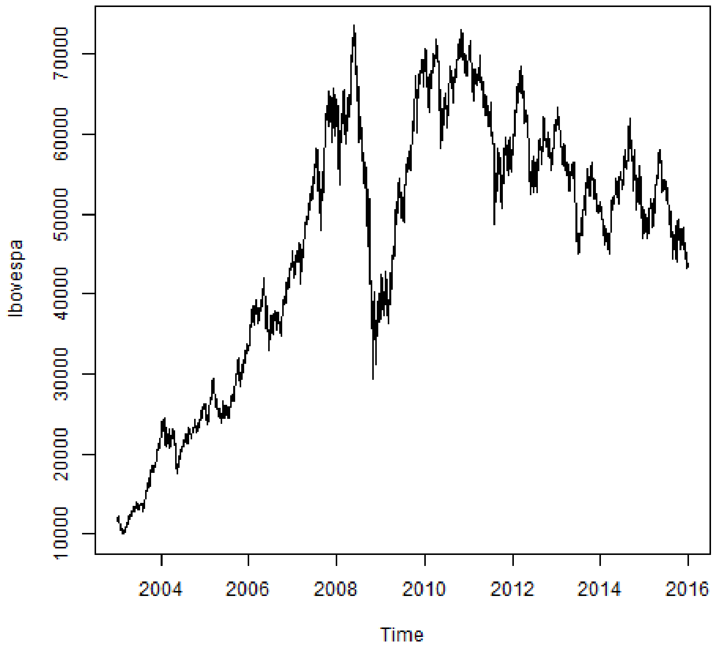
The Bovespa Index (Ibovespa) is the indicator of the average performance of stock prices traded on BM&FBovespa, calculated by the Exchange based on the prices of stocks with the highest volume traded in the last 12 months. We obtained The time series of the Ibovespa on the BM&FBovespa website on 10/21/2016. The series has daily frequency, beginning on 01/01/2003 and ending on 12/31/2015. The Figure 4.2 shows the evolution of this series during the period.

Table 4.5: Descriptive Statistics - Ibovespa

Mean	Minimum	Maximum	SD	Skewness	Kurtosis
46738.9552	9995	73517	16494.1146	-0.0525	7.9416

Source: Prepared by the author.

Figure 4.2: Bovespa Index 2003-2015



Data source: BM&FBovespa.

A trend of appreciation of the index is seen between January 2003 and May 2008. This trend can be explained by the improvement in the Brazilian macroeconomic fundamentals during the period, with an average economic growth of 4.2% per year, in addition to the high International liquidity, which encouraged the inflow of foreign capital. On

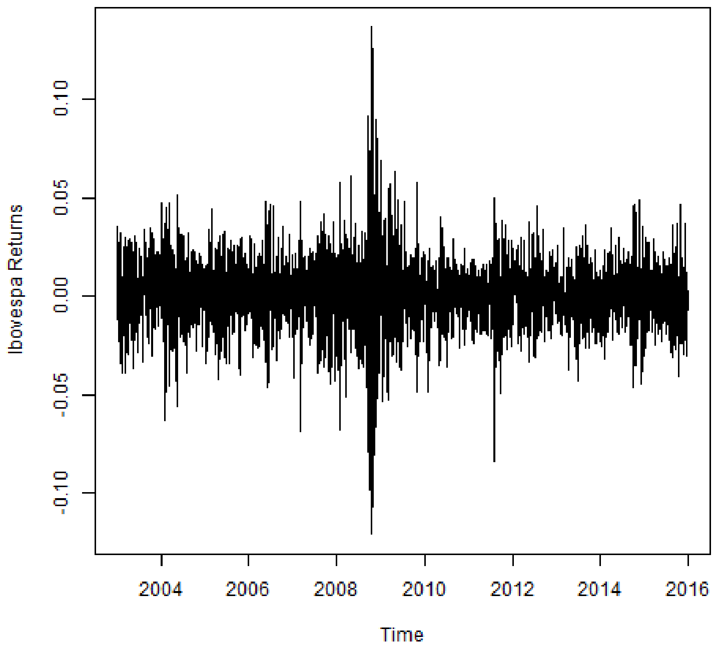
May 20, 2008, the Ibovespa reached 73.517 points, its highest closing level in its history, reacting to the news of the increase by S&P of Brazil's rating to the investment grade.

The reversal of the Ibovespa appreciation trend occurred with the subprime crisis in July 2008, when the index fell sharply. Even with its rapid recovery, boosted by the resumption of economic growth in 2010, the index showed a downward trend during the remaining period.

The Ibovespa returns were calculated from the following formula:

$$ReturnIbovespa_t = ln(Ibovespa_t/Ibovespa_{t-1})$$

Figure 4.3: Bovespa Index Returns 2003-2015



Data source: BM&FBovespa.

We test the existence of unit root through the Augmented Dickey-Fuller (ADF) test. And to test its stationarity we use the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test. According to the ADF test, the null hypothesis of presence of unit root is not rejected at the significance level of 5%. And according to the KPSS test we reject the null hypothesis of stationarity at the significance level of 5%. The statistics generated, as well as their corresponding p-values are shown in the Table 4.6.

Table 4.6: Tests - Ibovespa

	Estimate	p-value
ADF	-14.831	0.01
KPSS	0.6404	0.0189

Source: Prepared by the author.

4.4.3 Exchange Rate

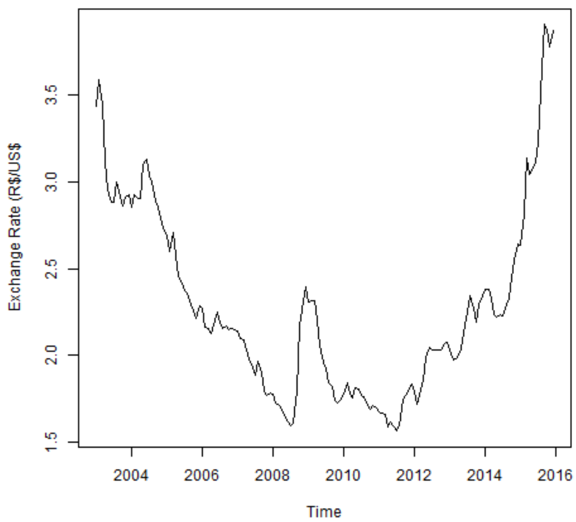
We collect the Exchange Rate (R$/US$) time series from the Brazil's Central Bank Time Series Management System at 10/21/2016. The series begins in January 2003 and ends in December 2015, with monthly frequency. The Figure 4.4 shows the evolution of this series during the period.

Table 4.7: Descriptive Statistics - Exchange Rate

Mean	Minimum	Maximum	SD	Skewness	Kurtosis
2.2783	1.5631	3.9058	0.5443	0.9751	3.3993

Source: Prepared by the author.

Figure 4.4: Exchange Rate (R$/US$) 2003-2015



Data source: BCB – Time Series Management System.

There is a clear trend of exchange appreciation between 2003 and the first half of 2008. This trend can be explained by the good economic performance presented by the country, together with the rise in commodity prices during the period Akram (2009) and the aforementioned reduction in the country risk.

As of August 2008, however, the worsening of the global financial crisis created a movement of flight to the quality by the investors, which generated a strong pressure of currency devaluation. The rapid recovery of the Brazilian economy and the maintenance of high interest rate differentials enabled, in 2010, the return of the exchange rate to levels observed before the crisis, continuing its recovery until July 2011. From 2012 until the end of the period, in December 2015, there is a strong movement of devaluation of the currency.

According to the ADF test, we reject the null hypothesis of presence of unit root at the significance level of 5%. And according to the KPSS test we reject the null hypothesis of stationarity at the significance level of 5%. The statistics generated, as well as their corresponding p-values are shown in the Table 4.8.

Table 4.8: Tests - Exchange Rate

	Estimate	p-value
ADF	0.8354	0.99
KPSS	1.1518	0.01

Source: Prepared by the author.

4.5 Estimation Methods

The purpose of this paper is to test whether the use of derivatives has a positive impact on firm value. For this, the following equation is estimated for the period from 2003 to 2015:

$$\begin{aligned} Q_{Tobin} = \alpha + \delta_t + \beta_{derivatives} * use\ of\ derivatives + \beta_{controls} * controls \\ + \beta_{interaction} * interaction\ terms + \epsilon_{i,t} \end{aligned} \tag{4.2}$$

Where α is the intercept, δ_t represents the temporal dummies and $\beta_{derivatives}$ is the coefficient of interest since it indicates the impact of the use of derivatives on the firm's value.

Following the methodology of previous work such as Allayannis and Weston (2001), Rossi (2008), the estimation was done initially via Pooled OLS, Fixed Effects and Random Effects. A problem that arises in the estimation of Equation 4.2 is the possibility of a lack of independence at the firm level, which would make the estimators inefficient. To control for this problem, as in Allayannis, Lel and Miller (2012), cluster robust standard errors (HUBER, 1967; WHITE, 1980; ARELLANO, 1987) were estimated considering the possibility that observations within a cluster (firm) are not independent.

As a way to verify the robustness of the results found, Equation 4.2 is estimated by an alternative approach, via Generalized Estimating Equations (GEE) (LIANG; ZEGER, 1986). GEE are an extension of the Generalized Linear Model (GLM) for panel data, and have been developed to produce more efficient and unbiased estimates for the parameters of the regression model when dealing with correlated and not normally distributed data, since it considers the correlation structure between the observations as one of its parameters and allows the specification of different probability distributions for the dependent variable. Although observations belonging to the same group may be correlated, it is assumed that observations in different groups are independent. GEE estimates are the same as those produced by OLS regression when the dependent variable is normally distributed and no correlation within response is assumed.

In order to write the GEE equations it is assumed that:

- The relationship between the mean of the response variable, μ_i , and the explanatory variables X_i, can be expressed in linear form through a known link function, g. This function is such that:

$$g(\mu_i) = X_i^{'}\beta, \tag{4.3}$$

  Where β is the parameter vector.

- The variance of the response variable can be expressed by a function known from the mean of this variable, that is,

$$V_i = f(\mu_i)/\phi, \tag{4.4}$$

  Where φ is the dispersion parameter.

Liang and Zeger define the estimate of β as the solution of the following differential equations system:

$$U_k(\beta) = \sum_{n=1}^{\infty} D_i V_i^{-1} S_i = 0 \tag{4.5}$$

Where, $D_i = \partial\mu_i/\partial\beta_k$ and $S_i = (y_i\text{-}\mu_i)$.

To use these equations for correlated data, since correlation matrix is generally unknown, Liang and Zeger specified a "working correlation matrix" embedded in the variance term of Equation 4.5. Considering $R_i(\alpha)$ such matrix, where α is a vector that completely characterizes $R_i(\alpha)$, Equation 4.5 becomes a covariance matrix for the i-th group:

$$V_i = A_i^{1/2} R_i(\alpha) A_i^{1/2} / \phi, \tag{4.6}$$

Where A_i is a diagonal matrix, with $f(\mu_i)$ as elements of the main diagonal.

The specification of the working correlation matrix accounts for the form of within-subject correlation of observations on the dependent variables. The geepack package, implemented in R, allows the specification of the following correlation structures, with examples for N = 3:

- Independence: Observations are independent

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

- Exchangable: All observations have the same correlation

$$\begin{bmatrix} 1 & \rho & \rho \\ \rho & 1 & \rho \\ \rho & \rho & 1 \end{bmatrix}$$

- AutoRegressive Order 1 (AR1): Correlation decreases as a power of how far apart two observations are

$$\begin{bmatrix} 1 & \rho & \rho^2 \\ \rho & 1 & \rho \\ \rho^2 & \rho & 1 \end{bmatrix}$$

- Unstructured: correlation between all observations may be different

$$\begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{bmatrix}$$

Where ρ_{ij} = corr(Y_{ij}, Y_{ik}) for the i^{th} subject at times j and k.

Since GEE is not a likelihood-based method, in order to choose the most appropriate correlation structure, the Pan's quasilikelihood under the independence model information criterion (QIC) (PAN, 2001) for each model is compared. The QIC is analogous to the AIC in evaluating competitive models fit. The model with QIC value closer to zero is chosen as the best model.

5 RESULTS AND DISCUSSION

5.1 Linear Panel Models

In the first model estimated the variable referring to the use of derivatives used was a binary dummy, assuming value 1 if the company uses some type of derivative contract in the year, or 0 otherwise. The model was estimated via Pooled OLS, Fixed Effects and Random Effects. In order to identity which of the three models is most appropriate to the data we initially perform a F-test for the joint significance of temporal effects and individual unobserved effects, and a Breusch-Pagan Lagrange Multiplier test (BREUSCH; PAGAN, 1980). The test results and their respective p-values are shown in the Table 5.1.

Table 5.1: F, BPLM and Hausman tests

Test	P-Value	Result
F-Test individual effect	0.0000	H0 rejected
F-Test time effect	0.0000	H0 rejected
BPLM individual effect	0.0000	H0 rejected
BPLM time effect	0.0104	H0 rejected
BPLM two ways effect	0.0000	H0 rejected
Hausman	0.0000	H0 rejected

Source: Prepared by the author.

The F test rejects the null hypothesis of non-significance of fixed effects, and the Breusch-Pagan Lagrange Multiplier test rejects the null hypothesis that the variance of unobserved heterogeneity is zero. Thus, both Fixed Effects and Random Effects models are preferred to the Pooled OLS model.

To choose between fixed effects and random effects, a Hausman test is performed, which rejects the null hypothesis of null covariance between unobsorved heterogeneity and explanatory variables. Thus, only the fixed effects model is consistent and is therefore chosen as the most suitable model for the data.

Table 5.2: Breusch-Pagan and Breusch-Godfrey tests

Test	P-Value	Result
Breusch-Pagan	0.003	H0 rejected
Breusch-Godfrey	0.000	H0 rejected

Source: Prepared by the author.

We then perform Breusch-Pagan (BREUSCH; PAGAN, 1979) and Breusch-Godfrey

(BREUSCH, 1978; GODFREY, 1978) tests to detect the presence of heteroscedasticity and serial correlation, respectively, in the residuals of the Fixed Effects model. The Breusch-Godfrey test confirms the already expected presence of serial correlation, given the clustered nature of the data. The Breusch-Pagan test identifies the presence of heteroscedasticity in the residuals.

To allow the violation of these two hypotheses, cluster robust standard errors are calculated according to the Arellano method. The coefficients, with the corrected standard errors are presented in the Table 5.3.

Table 5.3: Fixed Effects Model

	Dependent variable:
	log_tobin
Derivative	0.019
	(0.050)
Size	-0.137^{**}
	(0.058)
Liquidity	0.014
	(0.009)
ROA	0.206^{*}
	(0.120)
Leverage	0.411^{***}
	(0.039)
Deriv.exchange	-0.056
	(0.181)
Deriv.ibovespa	-0.00002
	(0.107)
Deriv.interest	0.038
	(0.127)
Observations	1,300
R^2	0.367
Adjusted R^2	0.303
F Statistic	34.195^{***} (df = 20; 1180)
Note:	*p<0.1; **p<0.05; ***p<0.01

Source: Prepared by the author.

The hypothesis that companies that use derivatives are priced by investors with higher market value is refuted by the Fixed Effects model. This model presents a positive, but statistically insignificant at the 5% level, coefficient for the relation between use of derivatives and market value.

As for the control variables, as in Lang and Stulz (1994) and Allayannis and Weston (2001), we obtain a negative and statistically significant relation between the market value of a firm and its size, measured by the logarithm of its total assets. There is a positive but statistically insignificant relationship between the liquidity and the value of the firms. This result is contrary to that predicted theoretically by Jensen (1986) and the results obtained by Rossi (2008).

Profitability coefficients indicate a positive relationship between how profitable the firm is, as measured by Return on Assets (ROA), and its market valuation. This coefficient is only significant at a significance level of 10%, however. The coefficient related to the company's leverage ratio is positive and statistically significant, confirming the importance of tax shields in relation to the payment of interest. All the coefficients of the interaction variables have small magnitude and are statistically insignificant.

5.2 GEE

GEE estimation requires specification of the distribution family of the dependent variable. Due to the fact that Tobin's Q is a continuous variable, greater than 0 and skewed to the right, the Gamma distribution family is chosen to perform the estimations. The figure below shows the probability density function and the cumulative distribution function of the Tobin's Q variable for the data:

Figure 5.1: Tobin's Q Density and Cumulative Distribution

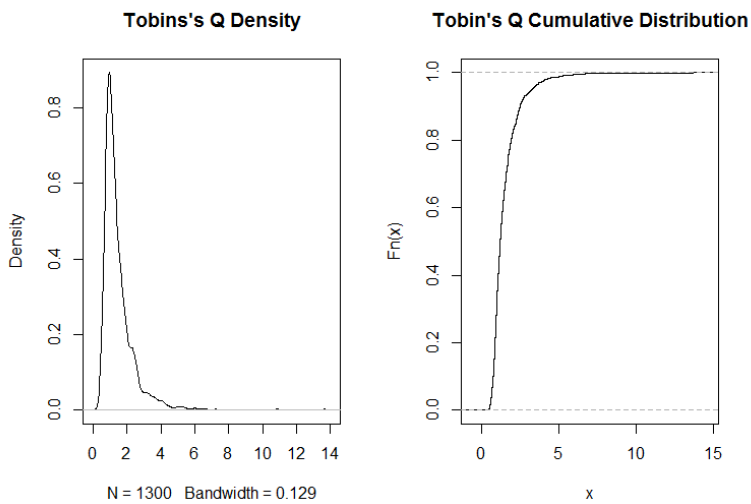


Table 5.4 shows the results of the estimation of Equation 4.2 via GEE, with the binary dummy variable for the use of derivatives and the different correlation structures:

Table 5.4: GEE coefficients with the binary independent variable

	Dependent variable:			
	Tobin			
	Independence	AR1	Exchangeable	Unstructured
der_dummy	0.141*	−0.027	0.043	0.032
	(0.074)	(0.046)	(0.060)	(0.046)
Size	−0.058***	−0.071***	−0.084***	−0.061***
	(0.021)	(0.021)	(0.029)	(0.017)
Liquidity	0.027***	0.003	0.016*	0.007***
	(0.009)	(0.003)	(0.008)	(0.002)
ROA	0.234	−0.019	0.199	0.070
	(0.238)	(0.063)	(0.164)	(0.061)
Leverage	0.412***	0.353***	0.405***	0.331***
	(0.048)	(0.026)	(0.036)	(0.031)
Deriv.exchange	−0.017	−0.023	−0.150	0.014
	(0.213)	(0.160)	(0.208)	(0.191)
Deriv.ibovespa	0.026	0.022	0.063	−0.002
	(0.134)	(0.063)	(0.119)	(0.218)
Deriv.interest	−0.032	0.012	0.012	0.026
	(0.162)	(0.099)	(0.143)	(0.281)
Number of clusters	100	100	100	100
Maximum cluster size	13	13	13	13
QIC	3554	3523	3560	3519
Note:	*p<0.1; **p<0.05; ***p<0.01			

Source: Prepared by the author.

The model estimated with an independence correlation structure for the dependent variable shows a statistically significant coefficient for the derivative use only at the 10 % significance level. However, such a specification ignores the aforementioned lack of firm-level independence, which makes the estimators inefficient. Among the other models, the one that presents QIC closer to 0 and therefore was chosen as the best model was the one with unstructured correlation structure. As in the estimation by Fixed Effects, the use of derivatives is not statistically significant to explain the market value of the companies. Also, as in previous model, Size and Leverage are significant at the 5% level, with negative and positive coefficients, respectively, although with different magnitudes. Unlike the previous result, Liquidity is significant at the 5% level, albeit with a low impact on market value. The Profitability estimate is insignificant. All three interaction variables are non-significant.

A second specification was tested using the multinomial categorical variable created to represent the use of derivatives. This variable assumes values between 0 and 10 according to the complexity of the derivative contracts used by the company. The results of the estimation with different correlation structures are presented in Table 5.5:

Table 5.5: GEE coefficients with the categorical independent variable

	Dependent variable:			
	Tobin			
	Independence	AR1	Exchangeable	Unstructured
Derivative	-0.023^{***}	-0.0004	-0.010	-0.005
	(0.007)	(0.006)	(0.006)	(0.033)
Size	0.049^{***}	0.053^{***}	0.061^{***}	0.123^{***}
	(0.012)	(0.012)	(0.015)	(0.013)
Liquidity	-0.010^{***}	-0.001	-0.007^{***}	0.014
	(0.002)	(0.001)	(0.001)	(0.097)
ROA	0.038	0.054^{**}	0.010	-0.165
	(0.035)	(0.024)	(0.039)	(0.306)
Leverage	-0.109^{***}	-0.072^{***}	-0.093^{***}	-0.030
	(0.013)	(0.011)	(0.012)	(0.038)
Deriv.exchange	0.038	0.009	0.065^{**}	0.045
	(0.029)	(0.019)	(0.031)	(0.330)
Deriv.ibovespa	-0.012	-0.002	-0.022	-0.052
	(0.020)	(0.009)	(0.018)	(0.195)
Deriv.interest	0.020	-0.007	0.009	0.053
	(0.019)	(0.012)	(0.019)	(0.048)
Number of clusters	100	100	100	100
Maximum cluster size	13	13	13	13
QIC	3536	3532	3537	10512
Note:	*p<0.1; **p<0.05; ***p<0.01			

Source: Prepared by the author.

As in the previous case, only the model using independence correlation structure presents a statistically significant coefficient. The model with QIC closest to 0 was the one with AR1 correlation. As in previous estimates, the use of derivatives has a statistically insignificant coefficient. Size and Leverage continue to be significant, but have opposite signs to those obtained previously. Most profitable companies have higher market value, as in previous estimates, but now with a significant coefficient at the 5 % level and the company's liquidity does not affect its market value. The interaction variables have coefficients with low absolute value and not statistically significant.

Despite the methodology used, the use of derivatives is not a statistically significant determinant of the market value of Brazilian firms. These results are consistent with the theory developed by Modigliani and Miller (1958) and the empirical results found by Jin and Jorion (2006), who analyzed American oil and gas companies between 1998 and 2001, and Serafini (2009), who analyzed the non-financial companies that compose the Bovespa index between 1999 and 2007. But they are inconsistent with the results of Allayannis and Weston (2001) and Rossi (2008), who found positive and significant relationships between the use of derivatives and market value for US and Brazilian companies, respectively.

The only statistically significant variables across all of the estimated models were Size and Leverage. The interaction variables were insignificant in both methodologies, revealing an independence between the macroeconomic scenario and the hedge premium paid by the investors.

6 CONCLUSION

In this study, we sought to identify the impact of the use of derivatives on the market value of Brazilian companies through an econometric analysis. In order to do so, we controlled other variables that the theory suggests should affect the firm's value: size, leverage, profitability and liquidity. In addition, we included in the model interaction variables between the use of derivatives and macroeconomic variables relevant to hedge strategies: interest, exchange and the Bovespa Index.

The estimation was done initially through parametric estimation methods for panel data, with Pooled OLS, Fixed Effects and Random Effects and using cluster-robust standard errors to deal with the problem of lack of independence of the observations at a firm-level, and alternatively through a semi-parametric method for dealing with clustered panel data, the Generalized Estimating Equations (GEE).

The results found in both methodologies indicate that the use of derivatives does not have a significant impact on the market value of Brazilian companies. These results show supporting evidence for the theory of Modigliani and Miller (1958), who predicted the irrelevance of the company's risk management policy for its market valuation. This may be due to the fact that investors cannot easily distinguish between the alternative uses of derivatives (for hedging, for speculation, or for managerial benefits).

Data were collected on all Brazilian non-financial companies traded throughout the period between 2003 and 2015 with the goal of building a balanced panel and facilitating the analysis. Later works may seek to correct the possible survival bias resulting from the sample selection methodology, analyze more companies, and include other control variables in the estimated model.

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Appendix A . PYTHON CODE

```
# -*- coding: utf-8 -*-
"""
@author: Lucas Konikiewez Matukait
"""

#Import and Activate Packages

import os
import pandas as pd
import numpy as np
import math
import matplotlib.pyplot as plt
import statsmodels.api as sm
import statsmodels.formula.api as smf
import numbers



#Import data and create panda dataframes for the variables.
deriv = pd.read_excel("~/Dados/Derivativos_2003.xlsx")
exchange = pd.read_csv("~/Dados/cambio_dolar_mensal.csv",
                       parse_dates=['Data'])
ibovespa = pd.read_csv("~/Dados/Ibovespa_diario.csv",
                       parse_dates=['Data'])
interest = pd.read_csv("~/Dados/DI1_SELIC_CETIP.csv",
                       parse_dates=['Data'])

exchange_anual = pd.read_csv("~/Dados/cambio_dolar_anual.csv",
                             parse_dates=['Data'], sep = ";")
ibovespa_anual = pd.read_csv("~/Dados/ibovespa_anual.csv",
                             parse_dates=['Ano'])
interest_anual = pd.read_csv("~/Dados/DI1_SELIC_CETIP_ANUAL.csv",
```

```
                              parse_dates=['Data'], sep = ";")


df = pd.DataFrame(index=range(0,184), columns=range(0,14))
size = pd.DataFrame(index=range(0,184), columns=range(0,14))
liquidity = pd.DataFrame(index=range(0,184), columns=range(0,14))
roa = pd.DataFrame(index=range(0,184), columns=range(0,14))
leverage = pd.DataFrame(index=range(0,184), columns=range(0,14))
deriv_exchange = pd.DataFrame(index=range(0,184), columns=range(0,14))
deriv_ibovespa = pd.DataFrame(index=range(0,184), columns=range(0,14))
deriv_interest = pd.DataFrame(index=range(0,184), columns=range(0,14))
forward = pd.DataFrame(0, index=range(0,100), columns=range(0,14))
future = pd.DataFrame(0, index=range(0,100), columns=range(0,14))
option = pd.DataFrame(0, index=range(0,100), columns=range(0,14))
swap = pd.DataFrame(0, index=range(0,100), columns=range(0,14))


'''
Convert the data panel on the use of derivatives to numbers, following
the rule:
If firm i did not use derivative contracts, deriv [i][j] = 0;
If firm i used forward contracts in year j, deriv [i][j] = 1;
If firm i used futures contracts in year j, deriv [i][j] = 2;
If firm i used call or put option contracts, deriv [i][j] = 3;
If firm i used swap contracts in year j, deriv [i][j] = 4;
If firm i used more than one type of derivative contract in year j,
deriv [i][j] = sum of the individual weights of each contract.
'''
for i in range (0,100):
    for j in range (0,14):

        if (deriv.iloc[i,j] == 0) :
            deriv.iloc[i,j] = 0

```

```
        if (deriv.iloc[i,j] == 't') :
            deriv.iloc[i,j] = 1
            forward.iloc[i,j] = 1

        if (deriv.iloc[i,j] == 'f') :
            deriv.iloc[i,j] = 2
            future.iloc[i,j] = 1

        if (deriv.iloc[i,j] == 'o') :
            deriv.iloc[i,j] = 3
            option.iloc[i,j] = 1

        if (deriv.iloc[i,j] == 's') :
            deriv.iloc[i,j] = 4
            swap.iloc[i,j] = 1

        if (deriv.iloc[i,j] == 'o,t') :
            deriv.iloc[i,j] = 4
            forward.iloc[i,j] = 1
            option.iloc[i,j] = 1

        if (deriv.iloc[i,j] == 's,t') :
            deriv.iloc[i,j] = 5
            forward.iloc[i,j] = 1
            swap.iloc[i,j] = 1

        if (deriv.iloc[i,j] == 's,f') :
            deriv.iloc[i,j] = 6
            future.iloc[i,j] = 1
            swap.iloc[i,j] = 1

        if (deriv.iloc[i,j] == 's,t,f') :
            deriv.iloc[i,j] = 7
            forward.iloc[i,j] = 1
```

```
                future.iloc[i,j] = 1
                swap.iloc[i,j] = 1

            if (deriv.iloc[i,j] == 'o,s') :
                deriv.iloc[i,j] = 7
                option.iloc[i,j] = 1
                swap.iloc[i,j] = 1

            if (deriv.iloc[i,j] == 'o,s,t') :
                deriv.iloc[i,j] = 8
                forward.iloc[i,j] = 1
                option.iloc[i,j] = 1
                swap.iloc[i,j] = 1

            if (deriv.iloc[i,j] == 'o,s,f') :
                deriv.iloc[i,j] = 9
                future.iloc[i,j] = 1
                option.iloc[i,j] = 1
                swap.iloc[i,j] = 1

            if (deriv.iloc[i,j] == 'o,s,t,f') :
                deriv.iloc[i,j] = 10
                forward.iloc[i,j] = 1
                future.iloc[i,j] = 1
                option.iloc[i,j] = 1
                swap.iloc[i,j] = 1


forward.iloc[:,0] = deriv.iloc[:,0]
future.iloc[:,0] = deriv.iloc[:,0]
option.iloc[:,0] = deriv.iloc[:,0]
swap.iloc[:,0] = deriv.iloc[:,0]
```

```
for i in range (0,100):
    deriv_exchange.iloc[i,0] = deriv.iloc[i,0]
    deriv_ibovespa.iloc[i,0] = deriv.iloc[i,0]
    deriv_interest.iloc[i,0] = deriv.iloc[i,0]

    for j in range (1,14):

        deriv_exchange.iloc[i,j] = (deriv.iloc[i,j] *
        exchange_anual.Retorno[j-1])

        deriv_ibovespa.iloc[i,j] = (deriv.iloc[i,j] *
        ibovespa_anual.Return[j-1])

        deriv_interest.iloc[i,j] = (deriv.iloc[i,j] *
        interest_anual.Retorno[j-1])

#Calculate the Tobin's Q, size, liquidity and return on assets
for i in range (1,184):

    #For each of the companies in the sample, it imports the dataframes
    #referring to its balance sheet and market value.
    balance_sheet = pd.read_excel(r'~\Dados\Balanços\balanco(%i).xlsx'
                                  % i, header = None)
    market_value = pd.read_excel(r'~\Dados\Valores\valor(%i).xlsx'
                                 % i, header = None)
    soma = 0


    #Tests whether the market value of firm i in year j is a number.
    #If yes, add 1 to the "soma" counter.
    for j in range (1, len(market_value.columns)):
        if isinstance(market_value.iloc[11][j], numbers.Number) :
            soma = soma + 1

```

```
    if (soma >= len(market_value.columns)-1 & len(market_value.columns)
        >= 14):

        #If the counter for company i is greater than or equal to 14,
        #the value of the first column in each dataframe is given the
        #name of the company as shown in its balance sheet.

        df.iloc[i][0] = balance_sheet.iloc[0][0]
        size.iloc[i][0] = balance_sheet.iloc[0][0]
        liquidity.iloc[i][0] = balance_sheet.iloc[0][0]
        roa.iloc[i][0] = balance_sheet.iloc[0][0]
        leverage.iloc[i][0] = balance_sheet.iloc[0][0]


        for k in range (1, 14):

            #For each year k, it calculates its Q of Tobin, according
            #to the formula used by Allayannis & Weston (2001), and
            #stores it in the panda dataframe "df".
            df.iloc[i][k] = ((balance_sheet.iloc[9][k] -
                   balance_sheet.iloc[160][k] +
                   market_value.iloc[11][k]) / balance_sheet.iloc[9][k]

            #For each year k, it designates the value of its total
            #assets for the panda dataframe "size".
            size.iloc[i][k] = math.log(balance_sheet.iloc[9][k])

            #For each year k, it calculates its current liquidity
            #through the formula: liquidity = current assets /
            #current liabilities, and stores it in the panda
            # dataframe "liquidity".
            liquidity.iloc[i][k] = (balance_sheet.iloc[10][k] /
```

```
                                    balance_sheet.iloc[77][k])

                #For each year k, it calculates its return on assets
                #through the formula: roa = net income / total assets,
                #and stores it in the panda dataframe "roa".
                roa.iloc[i][k] = (balance_sheet.iloc[202][k] /
                        balance_sheet.iloc[9][k])


                #For each year k, it calculates its leverage index through
                #the formula: leverage = long-term debt / total assets, and
                #stores it in the panda dataframe "leverage".
                leverage.iloc[i][k] = ((balance_sheet.iloc[9][k] -
                             balance_sheet.iloc[160][k]) /
                             balance_sheet.iloc[9][k])


#For each of the variables, remove the rows with null values.
df = df[pd.notnull(df[0])]
size = size[pd.notnull(size[0])]
liquidity = liquidity[pd.notnull(liquidity[0])]
roa = roa[pd.notnull(roa[0])]
leverage = leverage[pd.notnull(leverage[0])]
deriv_exchange = deriv_exchange[pd.notnull(deriv_exchange[0])]
deriv_ibovespa = deriv_ibovespa[pd.notnull(deriv_ibovespa[0])]
deriv_interest = deriv_interest[pd.notnull(deriv_interest[0])]

#Rename the columns of each Dataframe

df.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
size.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
liquidity.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
```

```
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
roa.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
leverage.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
deriv_exchange.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
deriv_ibovespa.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
deriv_interest.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
forward.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
future.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
option.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]
swap.columns = ['Empresas/Ano', 2003, 2004, 2005, 2006, 2007,
                2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015]


#Transform the Dataframes into the panel data format.

panel1 = pd.melt(deriv, id_vars=['Empresas/Ano'], value_vars=[2003,
                 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011,
                 2012, 2013, 2014, 2015])

panel2 = pd.melt(df, id_vars=['Empresas/Ano'], value_vars=[2003, 2004,
                 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013,
                 2014, 2015])

panel3 = pd.melt(size, id_vars=['Empresas/Ano'], value_vars=[2003, 2004
                 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013,
                 2014, 2015])
```

```
panel4 = pd.melt(liquidity, id_vars=['Empresas/Ano'], value_vars=[2003,
                 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012,
                 2013, 2014, 2015])

panel5 = pd.melt(roa,id_vars=['Empresas/Ano'], value_vars=[2003, 2004,
                 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013,
                 2014, 2015])

panel6 = pd.melt(leverage,id_vars=['Empresas/Ano'], value_vars=[2003,
                 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012,
                 2013, 2014, 2015])

panel7 = pd.melt(deriv_exchange,id_vars=['Empresas/Ano'], value_vars=
                 [2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011,
                  2012, 2013, 2014, 2015])

panel8 = pd.melt(deriv_ibovespa,id_vars=['Empresas/Ano'], value_vars=
                 [2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011,
                  2012, 2013, 2014, 2015])

panel9 = pd.melt(deriv_interest,id_vars=['Empresas/Ano'], value_vars=
                 [2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011,
                 2012, 2013, 2014, 2015])

panel10 = pd.melt(forward,id_vars=['Empresas/Ano'], value_vars=[2003,
                  2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012,
                  2013, 2014, 2015])

panel11 = pd.melt(future,id_vars=['Empresas/Ano'], value_vars=[2003,
                  2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012,
                  2013, 2014, 2015])

panel12 = pd.melt(option,id_vars=['Empresas/Ano'], value_vars=[2003,
```

```
                   2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012,
                   2013, 2014, 2015])

panel13 = pd.melt(swap,id_vars=['Empresas/Ano'], value_vars=[2003,
                   2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011,
                   2012, 2013, 2014, 2015])


#Merge the relevant columns of each of the panels.

panel_final = pd.merge(panel1, panel2,
                        on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel3,
                        on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel4,
                        on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel5,
                        on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel6,
                        on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel7,
                        on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel8,
                        on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel9,
                        on=('Empresas/Ano', 'variable'))
```

```
panel_final = pd.merge(panel_final, panel10,
                       on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel11,
                       on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel12,
                       on=('Empresas/Ano', 'variable'))

panel_final = pd.merge(panel_final, panel13,
                       on=('Empresas/Ano', 'variable'))


#Rename the columns of the final panel.

panel_final.columns = ['Empresa', 'Ano', 'Derivativo',
                       'Tobin', 'Size', 'Liquidity',
                       'ROA', 'Leverage', 'Deriv.exchange',
                       'Deriv.ibovespa', 'Deriv.interest',
                       'Forward', 'Future', 'Option',
                       'Swap']

panel_final.to_excel('panel_final.xls', index = False)
```

Appendix B . R SCRIPT

```r
#Author: Lucas Konikiewez Matukait

library(readxl)
library(gee)
library(plm)
library(geepack)
library(wgeesel)
library(MuMIn)
library(tseries)
library(car)
library(xtable)
library(stargazer)
library(lmtest)
library(stats)
library(texreg)


pbptest <-function(x, ...) {
  ## residual heteroskedasticity test based on the residuals of the
  ##demeaned model and the regular bptest() in {lmtest}

  if (!inherits(x, "plm")) stop("need to supply a panelmodel
                                      estimated with plm()")
  model <- plm:::describe(x, "model")
  effect <- plm:::describe(x, "effect")
  theta <- x$ercomp$theta

  ## retrieve demeaned data
  demX <- model.matrix(x, model = model, effect = effect, theta =
                            theta)
  demy <- pmodel.response(model.frame(x), model = model, effect =
                               effect, theta = theta)
```

```r

  Ti <- pdim(x)$Tint$Ti

  if (is.null(order)) order <- min(Ti)

  ## bgtest on the demeaned model:

  ## check package availability and load if necessary
  lm.ok <- require("lmtest")
  if(!lm.ok) stop("package lmtest is needed but not available")

  ## pbptest is the bptest, exception made for the method
  ##attribute
  dots <- match.call(expand.dots=FALSE)[["..."]]
  if (!is.null(dots$type)) type <- dots$type else type <-
    "Chisq"
  if (!is.null(dots$order.by)) order.by <- dots$order.by
  else order.by <- NULL

  auxformula <- demy~demX-1
  lm.mod <- lm(auxformula)
  return(lmtest::bptest(lm.mod, ...)) # call and return
  #lmtest::bptest
}


panel_temp <- read_excel("C:/Users/Lucas/Desktop/
                         Resultados2/panel_final.xls")

panel_temp$der_dummy<-0
for(i in 1: 1300){
  if (panel_temp$Derivativo[i] > 0)
    panel_temp$der_dummy[i] <- 1
}
```

```

panel_temp$log_tobin<-0
for(i in 1: 1300){
  panel_temp$log_tobin[i] <- log(panel_temp$Tobin[i])
}

panel_temp$id<-0
for(i in 0:12){
  for (j in 1:100) panel_temp$id[(100*i)+j] <- j
}

panel_final <- panel_temp[order(panel_temp$Empresa),]
panel_final$Deriv.exchange<- abs(panel_final$Deriv.exchange)
panel_final$Deriv.ibovespa<- abs(panel_final$Deriv.ibovespa)
panel_final$Deriv.interest<- abs(panel_final$Deriv.interest)
panel_final$Deriv.exchange_dummy<- (panel_final$Deriv.exchange *
                                      panel_final$der_dummy)
panel_final$Deriv.ibovespa_dummy<- (panel_final$Deriv.ibovespa *
                                      panel_final$der_dummy)
panel_final$Deriv.interest_dummy<- (panel_final$Deriv.interest *
                                      panel_final$der_dummy)
panel_final$Deriv.exchange_g<- (panel_final$Deriv.exchange *
                                  panel_final$Derivativo)
panel_final$Deriv.ibovespa_g<- panel_final$Deriv.ibovespa *
                                  panel_final$Derivativo
panel_final$Deriv.interest_g<- panel_final$Deriv.interest *
                                  panel_final$Derivativo

formula_gee <- Tobin ~ Derivativo + Size + Liquidity + ROA +
  Leverage + Deriv.exchange_g + Deriv.ibovespa_g + Deriv.interest_g
  + factor(Ano)
formula_bin <- log_tobin ~ der_dummy + Size + Liquidity + ROA +
  Leverage + Deriv.exchange_dummy + Deriv.ibovespa_dummy +
  Deriv.interest_dummy
```

```
#GEE estimation and model selection
gee_gamma_ind<-geeglm(formula_gee, data=panel_final, id=id,
                      family=Gamma, corstr="independence")
gee_gamma_ar1<-update(gee_gamma_ind, corstr="ar1")
gee_gamma_exch<-update(gee_gamma_ind, corstr="exchangeable")
gee_gamma_unstr<-update(gee_gamma_ind, corstr="unstructured")

selection1<-model.sel(gee_gamma_ind, gee_gamma_ar1, gee_gamma_exch,
                      gee_gamma_unstr, rank = QIC)


bin_gamma_ind<-geeglm(Tobin ~ der_dummy + Size + Liquidity + ROA +
                        Leverage + Deriv.exchange_dummy +
                        Deriv.ibovespa_dummy + Deriv.interest_dummy +
                        factor(Ano), data=panel_final,
                        id=id, family=Gamma(link = "log"),
                        corstr="independence")
bin_gamma_ar1<-update(bin_gamma_ind, corstr="ar1")
bin_gamma_exch<-update(bin_gamma_ind, corstr="exchangeable")
bin_gamma_unstr<-update(bin_gamma_ind, corstr="unstructured")

selection2<-model.sel(bin_gamma_ind, bin_gamma_ar1, bin_gamma_exch,
                      bin_gamma_unstr, rank = QIC)



#PLM estimation
fixed_bin <- plm(formula_bin, data=panel_final, model = "within",
                 index = c("Empresa", "Ano"),
                 effect = "twoways")
random_bin <- plm(formula_bin, data=panel_final, model = "random",
                  index = c("Empresa", "Ano"),
```

```
                    effect = "twoways")
pooling_bin <- plm(formula_bin, data=panel_final, model = "pooling")

#Cluster-robust standard errors
coef_fixed_bin <- coeftest(fixed_bin, vcov=vcovHC(fixed_bin,
                                                     cluster="group",
                                                     method="arellano"))
coef_pooling_bin <- coeftest(pooling_bin, vcov=vcovHC(pooling_bin,
                                                         cluster="group",
                                                         method="arellano"
coef_random_bin <- coeftest(random_bin, vcov=vcovHC(random_bin,
                                                       cluster="group",
                                                       method="arellano"))


#Test of individual and time effects for
plmtest(pooling_bin, type=c("bp"), effect = "time")
plmtest(pooling_bin, type=c("bp"), effect = "individual")
plmtest(pooling_bin, type=c("bp"), effect = "twoways")

#F Test for Individual and Time Effects
pFtest(fixed_bin, pooling_bin, data=panel_final, effect = "time")
pFtest(fixed_bin, pooling_bin, data=panel_final, effect = "individual")

#Tests of cross-section dependence
pcd_bin<-pcdtest(fixed_bin, test = c("cd"))

#Test of serial correlation for the errors
pbg_fixed_bin<-pbgtest(fixed_bin)

#Test for unit root
Panel.set <- plm.data(panel_final, index = c("Empresa", "Ano"))
adf_tobin <- adf.test(Panel.set$Tobin)
```

```
#Test for heteroskedasticity
bp_fixed <- pbptest(fixed_bin)

#Hausman test
haus_bin<-phtest(fixed_bin, random_bin)


#Coefficients of the selected models
summary(gee_gamma_ar1)
summary(bin_gamma_unstr)
coef_fixed_bin


#Plots and Tables
stargazer(pooling_bin, fixed_bin, random_bin,
          se = (list(coef_pooling_bin[,"Std. Error"],
                     coef_fixed_bin[,"Std. Error"],
                     coef_random_bin[,"Std. Error"])))

#cat("GEE AR1", capture.output(summary(gee_gamma_ar1)),
#file="summary_gee_gamma_ar1.txt", sep="\n", append=TRUE)
#cat("GEE AR1 BIN", capture.output(summary(bin_gamma_ar1)),
#file="summary_bin_gamma_ar1.txt", sep="\n", append=TRUE)

df <- data.frame(panel_final)
cols <- c('Tobin','Size', 'Liquidity', 'ROA', 'Leverage')
stargazer(df[, cols], type = "latex", summary.stat =
            c("min", "p25", "mean", "p75", "max",
            "median", "sd"))


par(mfrow=c(1, 2))
plot(density(panel_final$Tobin), main = "Tobins's Q Density")
plot(ecdf(panel_final$Tobin), main = "Tobin's Q Cumulative Distribution
```