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Nonlinear Foreign Exchange Exposure: Evidence from Brazilian Companies

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NONLINEAR FOREIGN EXCHANGE EXPOSURE: EVIDENCE FROM BRAZILIAN COMPANIES

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ABSTRACT

The paper analyzes the exchange rate exposure of a sample of non-financial Brazilian companies from 1999 to 2009 using a smooth transition autoregressive model (STAR). The results confirm the importance of using nonlinear models to address companies' exchange rate exposure. The results indicate that when compared to the linear model commonly used in literature, the nonlinear model leads to an increase in the number of firms exposed to exchange rate fluctuations, which allows a more accurate analysis of the impact of exchange rate fluctuations on the value of firms.

***Keywords**: Exchange rate exposure; Linearities; Exchange rate*

1. Introduction

Correctly measuring the impact of exchange rate fluctuations on the value of companies is of great importance, not only for investors who wish to find the correct balance between risk and return of their portfolios, but also for company managers who want to assess the result of their past decisions and take further decisions about different aspects of their firm, such as forms of financing, risk management and choice of investment projects.

The empirical literature on the subject has been developing intensively since the early 1990s. Initially, works such as Jorion (1990), Bartov and Bodnar (1994) and Amihud (1994) analyzed the exchange rate exposure of North American companies, and found that only a small fraction of companies in this country would be exposed to exchange rate fluctuations. Studies done for companies in other countries, using similar methodology to the work in the U.S. such as Bodnar and Gentry (1993) for Japan, the United States and Canada, showed similar results, corroborating the idea that exchange rate fluctuation would have an impact on only a small number of firms.

Since then, many studies have questioned the methodology used to estimate the foreign exchange exposure of firms, indicating that previous results were not robust in the specification used. One possibility raised in the literature was that linear models are not appropriate for estimating the exchange rate exposure of firms. Miller and Reuer (1998), Bartram (2004), Tai (2005), Koutmos and Martin (2003a) and Muller and Verschoor (2006) examined the possibility of using nonlinear models in the analysis of foreign exchange exposure of companies. On the whole, these studies confirmed the importance of nonlinearity, showing differences between processes of appreciation and depreciation and the presence of different impacts according to the magnitude of the exchange rate fluctuation. In the Brazilian case, Rossi (2008) and Merlotto et. al. (2008) estimate the foreign exchange exposure of Brazilian firms. None of them analyzed the non-linear hypothesis.

The Brazilian case makes the analysis of the existence of nonlinearity in foreign exchange exposure extremely interesting. After adopting a flexible exchange rate in 1999, the R$/US$ exchange rate not only had long periods of depreciation and appreciation, but also periods of high and low volatility; this means it is possible to identify the existence of nonlinearity in companies' foreign exchange exposure.

This study aims to assess the exchange rate exposure of non-financial Brazilian companies from 1999 to 2009, not only establishing a linear relationship as shown in most studies, but also examining the possible existence of a nonlinear relationship between exchange rate movements and the value of firms.

Initially, the linear model similar to the one used by Jorion (1990) is estimated. The results indicate that in a sample of 196 companies, approximately 20% of the firms have a statistically significant foreign exchange exposure. The results also show that depreciation of domestic currency is problematic for Brazilian companies. Everything else being equal, a 1% depreciation of the exchange rate leads, on average, to a 0.260% drop in return for the firms. Moreover, the number of firms which are negatively impacted by depreciation of the Brazilian Real is greater than the number of companies that benefit from these exchange rate movements.

Next, the assumption of exchange rate exposure linearity is tested against nonlinear smooth transition (STAR) models. The results confirm the importance of adopting a nonlinear model for the

analysis of foreign exchange exposure of firms. The assumption of linearity is rejected for 107 firms, or 54.6%, of the sample.

Finally, the Foreign exchange exposure of each firm is estimated according to the best model indicated by the data. The results confirm the negative relationship between currency devaluations and returns of companies and indicate that nonlinearity in the exchange rate exposure exacerbate the problem. On average, exchange rate movements of greater magnitude have a negative impact on the foreign exchange exposure of firms.

The work was ordered as follows: section 2 analyzes the theoretical motivation for the existence of nonlinearity in foreign exchange exposure. Section 3 presents the data used; the methodology is described in section 4; the results are reported in section 5; and section 6 presents the conclusions.

2. Theoretical arguments for nonlinearity in exchange rate exposure

Various reasons related to the behavior of the firm and investors can generate a nonlinear relationship between the exchange rate and the value of the firm.

2.1 Risk Management policy – Foreign Exchange Hedge

According to Muller and Verschoor (2006), one of the main factors to cause nonlinearity in the exchange rate exposure of firms is the policy of risk management either through the use of financial derivatives or hedging.

The use of financial derivatives can generate nonlinear payoffs caused by the exchange rate fluctuations, thereby influencing in a nonlinear way the firm's cash flow and, consequently, its value. The use of options, for example, allows the firm to make asymmetric gains, thereby influencing the firm's currency exposure in accordance with the magnitude of the exchange rate fluctuation. Several authors (Allayannis and Ofek (2001), Rossi (2008)) have demonstrated the existence of a relationship between exchange rate exposure and the risk management policy of firms.

2.2 Incorrect pricing of assets

Investors may find it difficult to interpret the impact of exchange rate fluctuations on the firm's value. As discussed by Muller and Verschoor (2006), several reasons may be behind the mistakes of investors.

The difficulty of interpreting the persistence of shocks can lead investors to incorrect conclusions. They are unable to correctly identify whether a shock is permanent or temporary, and therefore find it difficult to determine the real impact of the shock on the firm.

The lack of transparency in reports about the policy of protecting companies could also produce incorrect estimates of the firm's exposure, thus creating errors of assessment. Moreover, uncertainties about the future strategy to be adopted by the company may also lead to errors of assessment by investors.

Overall, the authors argue that these inaccuracies result in investors ignoring the effect of lower magnitude exchange rate fluctuations and, in contrast, reacting more strongly to movements of greater magnitude. This is particularly true with negative events, thus justifying the appearance of a nonlinear relationship between the exchange rate fluctuations and the firm's value.

2.3 Pricing policy and market structure

Firms may react asymmetrically to exchange rate fluctuations with respect to the policy of pricing their products. One possibility raised by international financial literature is that companies have a *pricing-to-market* policy, that is, they fix their prices in the currency of the country to which they are selling their product and not the domestic currency. Thus, there would not be an automatic transfer (*passthrough*) of exchange rate movement to the price charged by the exporting firm, but there would be a variation in the company's profit margin in line with the exchange rate movement.

In this case, the firm's passthrough of the exchange rate movements to the prices charged would depend on the magnitude of the exchange rate fluctuation: small exchange rate fluctuations would be absorbed by the firm and they would only change their prices with higher fluctuations, thereby creating nonlinear cash flow. Works such as Pollard and Coughlin (2003) confirm that the transfer of exchange rate movement to prices is nonlinear, depending on the magnitude of fluctuation.

2.4 Hysteresis in International Trade

Sharp exchange rate movements may cause companies to invest in new markets, especially exporters after major domestic currency depreciation. If the investment is made in a place with

investment irreversibility (high entry cost associated with a high cost in reduction of invested capital) the problem of hysteresis arises (Baldwin and Krugman, 1989). Even after the currency's appreciation, firms are required to maintain their investment in the same place even though operating losses may take place. This creates a situation where the exchange rate movements have a negative impact on the firm's value.

As discussed by Baldwin and Krugman (1989), the phenomenon of hysteresis creates nonlinearity in foreign exchange exposure of firms. This would only happen after greater magnitude exchange rate movements, since small movements would have no impact on the decision of entry and exit of firms.

2.5 Assymmetries due to government interference

Another reason for the existence of asymmetry is the possibility of government interference in the foreign exchange market, which mainly occurs through respective Central Banks.

Government interference is an indirect form of aid to companies, thereby limiting the risk of exchange rate fluctuations and, therefore, limiting the company's exchange rate exposure. The government would only act on the exchange rate movements in situations where the exchange rate exceeded a certain critical point, limiting the currency's volatility. An example would be the effect of depreciations on a company's foreign currency debt. By acting on the foreign exchange market, the government would limit the risk of non-payment of debts. This would then reduce the negative impact of depreciation on the company.

3. Methodology

The various factors presented indicate the possibility that a firm's value is affected in a nonlinear manner by exchange rate fluctuations. Several studies (Koutmos and Martin (2003), Koutmos and Knif (2004), Priestley and Odegaard (2004) among others) have modeled nonlinearity by differentiating between movements of currency appreciation and depreciation. However, the theoretical arguments presented indicate that movements of different magnitude are more likely to generate a nonlinear foreign exchange exposure.

Thus, we chose to model exchange rate exposure nonlinearity using a STAR model (Smooth Transition Autoregressive Model). This model is more appropriate because it is expects that a firm's currency exposure will not change suddenly, but moves smoothly according to the magnitude of exchange rate variations. The estimated model can then be represented as follows:

$$r_{i,t} = \alpha + \beta_i^m * r_{m,t} + \left(\beta_i^S + \beta_i^{S'} * M_i\left(\gamma, c, z_{t-d}\right)\right) * \Delta S_t + \varepsilon_{i,t} \quad (1)$$

Where $r_{i,t}$ indicates the return of firm i at time t. $r_{m,t}$ represents the market portfolio return at time t and ΔS_t indicates the exchange rate variation at time t.

The term $\left(\beta_i^S + \beta_i^{S'} * M_i\left(\gamma, c, z_{t-d}\right)\right)$ represents the firm's exchange rate exposure, which can be broken down into two terms. The first term, β_i^S, indicates the linear portion of the exchange rate exposure and the second term $\beta_i^{S'} * M_i\left(\gamma, c, z_{t-d}\right)$ represents the nonlinear part of the exchange rate exposure.

M_i is a function of continuous and smooth transition that will vary according to the firm in question, γ is the velocity of transition between the regimes, c is the point where there is a change of regime and z_{t-d} is the transition variable. The model therefore allows the exchange rate exposure to vary according to the distance of the exchange rate to a threshold value (*threshold*). The usual interpretation is that the model has two regimes associated with the end of the function of transition, where the transition takes place in a smooth way.

The literature shows the possibility of different functions of transition. This work uses the two main functions found in the literature: exponential and logistic. The functions have the following equation:

Exponential Function: $M(\gamma, c, .z_{t-d}) = \{1 + \exp[-\gamma(z_t^i - c)]\}^{-1}, \gamma > 0$ (2)

Logistic Function: $M(\gamma, c, z_{t-d}) = 1 - \exp[-\gamma(z_t^i - c)^2]$ (3)

The exponential function has values between 0 and 1. It is interesting to note that this is symmetric around the threshold. When $\gamma \to -\infty$, the exponential function tends to 0 and when $\gamma \to +\infty$, the function tends to 1; in both cases, the exchange rate exposure of the firm becomes linear. With the exponential function, the function's symmetry means the magnitude of the distance between the transition variable and the threshold is important, whether negative or positive.

The logistic function also has the property of varying between 0 and 1, which means no matter which function is used, the exchange rate exposure of firm varies between β_i^S and $\beta_i^S + \beta_i^{S'}$. If $\gamma = 0$ the model becomes linear, and if $\gamma \to \infty$, the model becomes an autoregressive threshold (ART). Unlike the exponential function, for the logistic function, both the position of the transition variable (above or below the threshold) and the distance between the transition variable and the threshold are important for determining the function value. That is, the model allows differences between currency depreciation and appreciation.

The methodology used to estimate the equation (1) is consistent with that proposed by Teräsvirta (1998) and Dijk et. al. (2002). Initially, the most appropriate linear model is determined for the data. In this work, the standard model for estimating exchange rate exposure is adopted as proposed by Jorion (1990). Afterwards, the hypothesis of nonlinearity is tested against the exponential and logistic models using the test proposed by Luukonen et al. (1988). If the hypothesis of linearity is rejected, the model most appropriate for the data - exponential or logistic –is tested. Therefore, the model indicated by the tests is estimated by the method of maximum likelihood. Finally, diagnostic tests are carried out to check possible specification problems.

4. Data

Share price data was collected from the website Economática. The study used all the weekly data of 196 non-financial Bovespa-listed companies from February 1999 to March 2009. The analysis began in 1999 in order to coincide with the period of flexible exchange rates in the country.

Some parameters were used to construct the sample. The data cover all active firms at the end of the sample period. Only data from firms with at least 24 months of trading were used to ensure a minimum of information for estimating exchange rate exposure. Additionally, the sample only included companies that traded for at least 80% of the weeks and that went no more than 3 weeks without trading. It is worth noting that the sample of 196 companies represents more than half of all non-financial companies in the country (360), according to Economática.

Unlike Muller and Verschoor (2006), the analysis was developed for all companies, not only the multinationals or exporters because there are other reasons besides foreign currency income that are important components of foreign exchange exposure for Brazilian companies. One example is the importance of debt acquired in foreign currency.

The share price data were extracted from the weekly closing prices, always using the value of the last trade that occurred in the week. The log-return prices were then calculated to determine the company's share return.

The use of weekly, rather than daily, data was chosen because sometimes the market takes a while to understand and realize the effects of exchange rate on various asset prices, so in the short term it is harder to properly monitor a company's foreign exchange exposure. In fact, many works, such as Rossi (2008), Dominguez and Tesar (2006), show an increase in the number of companies exposed to the exchange rate when weekly or monthly data are adopted instead of daily data.

Table 1 shows the distribution of firms by year. The data in Table 1 indicate that 74 companies remained in the sample during the whole period. It is worth noting that there was a significant increase in the number of businesses after 2005 due to the large number of IPOs that occurred in that period. On average, the sample gives 301 observations per company, or approximately 6 years of returns per share.

Table 1 – Sample distribution

Table 1 shows the distribution of the number of firms during the analyzed period.

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Number of Firms	74	81	82	87	90	102	109	134	193	196	196

The data presented in Table 2 indicate that firms in the sample are distributed throughout various sectors of activity, and that there is no dominance of any sector. Table 2 shows that

construction, electrical energy and the mining and steel industry are the sectors with the highest number of firms in the sample.

Table 2- Distribution of sample firms per activity sector
Table 2 shows the distribution of firms in different activity sectors. The sector classification of the website Economática is used.

Sector	Number of firms
Agriculture and fishing	4
Food and Beverage	12
Commerce	10
Construction	24
Electronics	6
Electrical Energy	21
Mining and Steel	19
Machines, Vehicles and parts	12
Paper and cellulose	4
Petrochemicals	15
Telecommunications	14
Textiles	9
Transport and Services	13
Others	33
Total	196

For exchange rate data, weekly closing values of the same days were used in the stock price analysis. The R$/US$ rate was used, ie, positive values of the exchange rate variation are indicative of depreciation of the Real.

Unlike other works, an exchange rate weighted by the country's international trade was not used since Muller and Verschoor (2006) showed that the use of such a rate reduces the significance of the exposure. As most Brazilian international trade is expressed in US dollars, the R$/US$ rate was chosen.

The Ibovespa index was used as the market portfolio. Both the exchange rate and the Ibovespa index were collected directly from the Central Bank website. Table 3 presents the descriptive statistics of variables used in the study.

Table 3 – Descriptive Statistics
Table 3 presents the descriptive statistics of variables used in the analysis. ΔS represents the change in the R$/US$ rate. IBOVESPA represents the return of the IBOVESPA index. The data show weekly periodicity. The analysis period is from February 1999 to March 2009.

	ΔS	**IBOVESPA**
Mean	0.020%	0.318%
Median	-0.156%	0.631%
Standard Deviation	2.411%	4.44%
Maximum	11.72%	16.84%
Minimum	-9.40%	-22.33%
Observations	531	531

5. Results

As discussed above, in the first stage, the results of the linear model are considered. Afterwards, the results of testing and estimation of the nonlinear model are presented.

5.1 Linear Model

Using the model estimated by Jorion (1990), the following linear specification was estimated. The results are in Table 4.

$$r_{i,t} = \alpha + \beta_i^m * r_{m,t} + \beta_i^S * \Delta S_t + \varepsilon_{i,t} \quad (4)$$

Table 4 – Results of estimation of the Linear Model

Table 4 presents the results of the equation's estimate (4). $r_{i,t}$ represents the return of firm i at time t. $r_{m,t}$ indicates the market return (Ibovespa). ΔS_t is the variation of the R$/US$ exchange rate in the period. The estimation was carried out by ordinary least squares with robust covariance matrix for the presence of heteroskedasticity. $N^+_{5\%}$ and $N^+_{10\%}$ indicate the number of firms with positive and statistically significant exposure, respectively, at 5% and 10% level of significance. $N^-_{5\%}$ and $N^-_{10\%}$ indicate a negative and statistically significant exposure. N indicates the total number of firms used in the analysis.

Coefficient	Mean	Median	Standard Deviation	Maximum	Minimum
Constant	-0.003	-0.004	0.0091	0.039	-0.038
Market Return (β_i^m)	0.564	0.544	0.294	1.555	-0.557
Exchange Rate Exposure (β_i^S)	-0.260	-0.197	0.503	1.714	-3.100

$N^+_{5\%}$	$N^-_{5\%}$	$N^+_{10\%}$	$N^-_{10\%}$	N
9	25	12	44	196

The results presented in the table indicate that the market risk is lower than 1 for a considerable percentage of the sample firms, which indicates the possible fact that Brazilian firms are diversified to the point of reducing market risk.

Table 4 shows the pattern of exchange rate exposure of Brazilian companies. Considering a significance level of 5%, 34 companies or 17.3% of firms have a statistically significant foreign exchange exposure; this proportion is higher than that shown by Jorion (1990) and Muller and Verschoor (2006) for North American companies. This number rises to 56 companies or 28.6% of the sample with a 10% level of significance. Therefore, regardless of the presence of nonlinearity, it can be seen that the exchange rate fluctuations affect a reasonable proportion of Brazilian companies.

Another characteristic of the currency exposure of Brazilian companies presented in Table 4 is that the mean (-0.260) and median (-0.197) are negative. This means that domestic currency depreciation against the US dollar leads to a fall in return for Brazilian companies. In addition, not only the mean, but also the distribution of foreign exchange exposure of firms, indicates a negative impact from currency devaluation. These results show that the number of firms with negative and statistically significant exposure is greater than the number of firms with positive and significant exposure.

According to Rossi (2008) this result can be explained by the fact that Brazilian companies have significant foreign currency debt, which creates a discrepancy in the monetary composition of their assets and liabilities, so devaluation has a negative impact on the firm's value. The author also shows that since the adoption of flexible exchange rates, the problem has decreased; however, according to the results presented in table 4, it is still relevant for the Brazilian economy.

5.2 Nonlinear Models

The model suggested by Teräsvirta (1998) and Dijk et. al. (2002) is followed. Initially, the assumption of linearity was tested against the nonlinear STAR models. The test suggested by

Luukkonen et al. (1988) was chosen. The test is based on a third-order approximation of the logistic function around the point γ=0 (null hypothesis of linearity). The test was used; however, although it was designed to test the logistic model (LSTAR), Teräsvirta (1994) argues that the test has power against exponential type linearity (ETL). Due to the sample size and number of parameters to be estimated, this study used the F version of the LM test of nullity of parameters (Teräsvirta, 1998).

The squared deviation of the exchange rate was defined as the model's transition variable. This variable is appropriate as it allows the analysis of the dependence of the exchange rate exposure with respect to the magnitude of the change in the exchange rate and has the statistical property of stationarity, needed for smooth transition models. The threshold used will then be the mean during the sample period of variable transition.

The choice between the exponential and logistic model is made using the procedure described by Van Dijk et. al. (2002). It is a common F test of exclusion of variables in the equation – which helps to test the linearity model. One can see which hypothesis of the parameters is most strongly rejected and determine which specification is the most appropriate. Finally, the model is estimated by ordinary least squares. Table 5 presents the results.

The results in Table 5 indicate that the null hypothesis of linearity of the model was rejected for 107 companies, or 54.6%, of the sample. This is a first indication of the importance of considering nonlinearity when estimating exchange rate exposure of Brazilian companies. Among the 107 companies that rejected the linear model, 35 rejected it in favor of the logistic model, but the majority (72 companies) rejected linearity in the direction of adopting a specification that uses the exponential model.

Table 5 – Results of estimation of Foreign exchange exposure

Table 5 presents the results of the estimation of the nonlinear model specified by equation (1). Panel A shows the test result of the linear model specified by equation (4). The exponential model corresponds with the use of a transition function specified by (2). The logistic model corresponds with the use of a function as specified by (3). Panel B shows the results of the estimations. The nonlinear model was only estimated if the linearity test rejected the linear model. $N^{+}_{5\%}$ and $N^{+}_{10\%}$ indicate the number of firms with positive and statistically significant exposure, respectively, at 5% and 10% levels of significance. $N^{-}_{5\%}$ and $N^{-}_{10\%}$ indicate a negative and statistically significant exposure. N indicates the total number of firms used in the analysis.

Panel A – Results of the linearity tests for exchange rate exposure

Number of companies in which H0: Linear exchange rate is rejected	H1 : Exponential Model	72
	H1 : Logistic Model	35

Panel B – Results of estimation of Foreign exchange exposure

Coefficient	Mean	Median	Standard Deviation	Maximum	Minimum	$N^{+}_{5\%}$	$N^{-}_{5\%}$	$N^{+}_{10\%}$	$N^{-}_{10\%}$	N
Constant	-.0012	0.0001	0.0092	0.050	-0.052					
Market return (β_i^m)	0.560	0.554	0.296	1.454	-0.557					
Linear Exchange Rate exposure (β_i^S)	-0.222	-0.182	0.512	1.714	-2.836	9	29	13	44	196
Nonlinear Exchange Rate exposure ($\beta_i^{S'}$)	-.0278	-0.0238	0.056	0.164	-0.202	10	45	15	59	

Panel C- Synthesis of the Companies' Exchange rate exposure

Number of companies with statistically significant linear and nonlinear exposure (5% / 10%)	12 / 20
Number of companies with statistically significant linear or nonlinear exposure (5% / 10%)	81 / 111
Number of companies which have only statistically significant nonlinear exposure (5% / 10%)	43 / 54
Number of companies with statistically significant linear exposure (5% / 10%)	26 / 37

Thus it is evident that although the sign function (depreciation or appreciation) of the exchange rate change is important, the magnitude of the movement is more important in determining a firm's exchange rate exposure. This result contradicts the arguments about the importance of nonlinearity that emphasize the dependence of the exchange rate exposure with respect to the magnitude of movements in the exchange rate.

Panel B, presented in Table 5, shows the results of the estimation of exchange rate exposure of firms. It is important to stress that if the test does not reject the null hypothesis of the adequacy of using the linear model, it is used for estimation. So, for 89 companies, the linear model was considered the most appropriate. For the other 107 companies, equation (1) was estimated by considering a function of exponential or logistic transition according to the results presented by the tests.

The results contained in table 5 confirm some results presented for the linear model with emphasis on the fact that the mean exchange rate exposure of Brazilian companies considering only the linear part is negative (-0.222), which indicates that domestic currency devaluations cause a fall in return for Brazilian firms.

The results presented in panel B also confirm the importance of using nonlinear models when analyzing foreign exchange exposure of firms. Considering a significance level of 5%, the results show that 55 firms (28.1% of the sample) have a statistically significant term corresponding to the nonlinear portion of foreign exchange exposure. This number grows to 74 companies (37.7% of the sample) when one considers a 10% significance level. In other words, in line with Muller and Verschoor (2006), the results confirm that the use of nonlinear models increases the number of firms with statistically significant foreign exchange exposure.

Besides the statistical significance, the use of nonlinear models has an economically relevant result. On average, companies have a nonlinear negative foreign exchange exposure, i.e., movements of greater magnitude of the exchange rate exacerbate problems related to domestic currency devaluation. Thus, strong exchange rate movements usually linked to financial crises have a larger impact on the foreign exchange exposure leading to a greater fall in return for the firms than with small exchange rate movements.

Panel C, in Table 5, summarizes the estimation of the linear model. Again using the 5% level of significance, 12 companies (6.12% of the sample) have statistically significant linear and nonlinear exposures. Confirming the importance of the exchange rate for Brazilian firms, about 41% of the sample (81 companies) has some kind of exchange rate exposure. Finally, the importance of nonlinear exposure can be seen as 43 companies have only this type of exposure compared to 26 that only have a linear foreign exchange exposure.

6. Conclusion

This paper analyzes the exchange rate exposure of Brazilian non-financial firms during the period of flexible exchange rates from 1999 to 2009 and, unlike other studies, examines the importance of nonlinearity in determining the exposure of Brazilian companies to exchange rate fluctuations.

The results indicate that the use of a nonlinear smooth transitions (STAR) model increases the number of firms with statistically significant exposure to exchange rate movements and is thus more suitable for the analysis of Brazilian firms. The results show that although the proportion of firms with linear exposure is significant, when nonlinearity is added to the model, the number rises substantially. Finally, the results show that depending on the level of significance used, about 50% of the sample has some type of exchange rate exposure.

The results show that domestic currency devaluation is problematic for Brazilian firms. This is indicated by the negative value of the mean exchange rate exposure of firms as well as by the distribution of foreign exchange exposure where there a greater number of firms experience a reduction in their returns after devaluation of the Real. Furthermore, the results suggest that

movements of greater magnitude in the exchange rate exacerbate this problem because of the significance of nonlinearity.

These results are important for economic policy makers. They can rationalize the possibility of intervention in the foreign exchange market since movements of greater magnitude in the rate lead to an increase in exchange exposure of firms. Therefore, this opens the possibility that one of the objectives of policy is the smoothing of movements in the exchange rate in order to reduce the effect on firms. As a future research, it is important to know if there is a reverse causality where the desire to smooth the movement of the exchange rate leads firms to neglect their policy of managing risk, as discussed by Chang and Velasco (2006).

References

Adler, M. e Dumas, B. 1984. .Exposure to currency risk: Definition and Measurement. Financial Management 13, 41-50.

Allayannis, G. e Ofek, E. 2001. Exchange rate exposure, hedging and the use of foreign currency derivatives. Journal of International Money and Finance 20, 273-296.

Amihud, Y. 1994. Exchange rates and the valuation of Equity shares. In Y. Amihud and R.M. Levich (eds.), Exchange rates and Corporate Performance (pp.49-59). New York: Irwin.

Bartov, E. e Bodnar, G. 1994. Firm valuation, earnings expectation, and the exchange rate exposure effect. The Journal of Finance 44, 1755-1786.

Bartram, S. 2004. Linear and nonlinear foreign exchange rate exposure of german nonfinancial corporations. Journal of international money and finance 23, 673-699.

Baldwin, R. e Krugman, P. 1989. Persistent trade effects of large exchange rate shocks. The Quarterly Journal of Economics 54, 635–654.

Bodnar, G. e Gentry, W. 1993. Exchange rate exposure and industry characteristics: evidence from Canada, Japan and the USA. Journal of International Money and Finance 12, 29-45.

Chang, R. e Velasco, A. 2006. Currency mismatches and monetary policy: A tale of two equilibria, Journal of International Economics 69, 150-175.

Dominguez, K. e Tesar, L. 2006. Exchange rate exposure. Journal of International Economics 68, 188-218.

Jorion, P. 1990. The exchange rate exposure of US multinationals. Journal of Business 63, 331–45.

Koutmos, G. e Knif, J. 2004. Exchange rate exposure: evidence from Finnish stock returns. Working Paper, Fairfield University.

Koutmos, G. e Martin, A. 2007. Modeling time variation and asymmetry in foreign exchange exposure. Journal of Multinational Financial Management 17, 61-74.

Koutmos, G. e Martin, A. 2003a. Asymmetric exchange rate exposure: theory and evidence. Journal of International Money and Finance 22, 365–383.

Koutmos, G. e Martin, A. 2003b. First and second moment exchange rate exposure: evidence from U.S. stock returns.Financial Review 38, 455–471.

Luukkonen, R.; Saikkonen, P. e Teräsvirta,T. 1988. Testing linearity against smooth transition autoregressive models. Biometrica 75, 491-499.

Merlotto, J.; Pimenta, T. e Rosifini, V. 2008. A exposição ao risco de câmbio e o valor das empresas: uma análise no mercado de ações brasileiro no período de 1999 a 2003. Revista de Administração Eletrônica 1, 1-12.

Muller, K. e Reuer, J. 1998. Asymmetric Corporate Exposures to Foreign Exchange Rate Changes. Strategic Management Journal 19, 1183-1191.

Muller, A. e Verschoor, W. 2006. Asymmetric foreign exchange risk exposure: Evidence from U.S. multinational firms. Journal of Empirical Finance 13, 495-518.

Pollard, P. e Coughlin, C. 2003. Size matters: asymmetric exchange rate pass-through at the industry level. Working Paper. The Federal Reserve Bank of St. Louis.

Priestley, R. e Odegaard, B. 2004. Exchange rate regimes and the price of exchange rate risk. Economics Letters, 82, 181-188.

Rossi, J. 2008. Corporate Foreign Vulnerability, Financial Policies and the Exchange Rate Regime: Evidence from Brazil. Ibmec São Paulo Working Paper, 2008.

Tai, C. 2005. Asymmetric currency exposure of U.S. bank stock returns. Journal of Multinational Financial Management 15, 455–472.

Teräsvirta, T. 1994. Specification, estimation, and evaluation of smooth transition autoregressive models. Journal of the American Statistical Association 89, 208-218.

Teräsvirta, T. 1998. Modeling economic relationships with smooth transition regressions. P. 507-552 em: Ullah, A., e D.E.A. Giles, editors, “Handbook of Applied Economic Statistics”, New York: Marcel Dekker, Inc.

Van Dijk, D., Teräsvirta, T. e Franses, P. 2002. Smooth Transition Autoregressive Models – A Survey of Recent Developments. Econometric Reviews 21, 1-47.