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Abstract

Brady bond securities represent a substantial fraction of emerging markets countries internationally tradable sovereign debt. The credit risk spread above and beyond the U. S. treasury curve for these securities is usually large in size and volatility. Moreover, most Brady bonds carry embedded options that lead to the existence of an Option-Adjusted Spread, OAS, which increases their risk profiles. In this paper we present an empirical study of the dynamics of Brady bonds OAS using a Heath, Jarrow and Morton term structure pricing model. The dynamics of the spread shows that the proper risk management and pricing of these securities require the consideration of volatility in addition to the magnitude of the sovereign risk spread. That is, the proper risk measure for these securities would be the pair (OAS, OAS Volatility). A study of implied default probabilities is also presented. Our analysis is illustrated with bonds from Brazil, Argentina, Mexico, Poland, Bulgaria and the Philippines.

Key Words: Pricing interest rate derivatives, credit risk, risk management, term structure models, Brady bonds.

JEL Code: G13, C63, F34 .

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Resumo

Os títulos Brady representam uma fração substancial das dívidas soberanas de países emergentes negociadas nos mercados internacionais. O spread de crédito acima das taxas do tesouro norte-americano para estes títulos é usualmente alto em termos de sua magnitude e volatilidade. Além disso, a maioria dos títulos Brady possuem opções de compra embutidas que necessitam ser levadas em consideração quando da determinação do spread de risco, que quando isto ocorre, este é denominado de "OAS" (option-adjusted spread). A presença destas opções embutidas contribui para um incremento no risco destes títulos. Neste artigo apresentamos uma análise empírica da dinâmica do OAS dos títulos Brady através do modelo de apreçamento de derivativos na estrutura termo de Heath, Jarrow and Morton. A análise da dinâmica do *spread* indica que a gestão de risco e o apreçamento destes títulos requerem a consideração da volatilidade do *spread* conjuntamente com a sua magnitude. Isto é, a medida de risco apropriada para estes títulos seria o par (OAS, Volatilidade do OAS). Apresentamos também um estudo das probabilidades de default embutidas nestes spreads. Nossa análise é ilustrada com títulos do Brasil, Argentina, México, Polônia, Bulgária e Filipinas.

1. Introduction.

Brady bond securities represent a substantial fraction of emerging markets countries internationally tradable sovereign debt¹. These bonds allow an investor to invest in debt of emerging markets countries without undertaking currency risk. Brady bonds were created as a solution to the emerging markets debt crisis of the 1980's. These bonds resulted from the exchange of emerging markets commercial loans (sometimes defaulted loans) into new securitized bonds. The objective of that exchange was to reduce and restructure the old debt of these countries in order to allow them to achieve economic growth and pay their obligations. It was mandatory for these countries to review their economic policies before entering that plan. The creation of these bonds also makes possible for the original lenders to trade these debts in the secondary market allowing

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¹See for instance, the Bulletin of the EMTA, 2000, page 5.

them to reduce or increase their positions on a certain emerging market country. Therefore, the emerging markets part of their portfolios risk exposure can be managed according to their views on the economic fundamentals of these countries. Brady bonds are named after former U.S. Treasury Secretary Nicholas Brady, who led the debt reduction plan that resulted in the creation of these bonds².

We will analyze bonds from Brazil, Argentina, Mexico, Poland, Bulgaria and the Philippines. We selected these countries because they represent, together, about 80 percent of the market capitalization of the J. P. Morgan EMBI index and 70 percent of the market capitalization of the J. P. Morgan EMBI+ index, two of the most important indices for the market³. They are also well spread geographically, representing Latin American, Eastern European and Asian fixed income markets

At first, we will discuss the main sources of risk of Brady bonds. These sources of risk are explained by the existence of a spread over the US Treasury interest rate curve. The main sources of risk are: *default*, *liquidity* and *volatility* risk. These risks are discussed in section II. Since the bonds we will analyze also have embedded options, we have to consider these spreads as "Option Adjusted Spreads" (OAS). For the proper pricing of these options, we use in the analysis an extension of the Vasicek (1977) model that is compatible with the Heath, Jarrow and Morton (1992) framework that was developed independently by Hull and White (1990) and Jamshidian (1991). The OAS and its pricing model are discussed in section III. Brady bonds are also very volatile so their embedded options value are high, increasing the risk of these bonds. In section IV we present the main contribution of this paper: a comprehensive statistical analysis of Brady bond spreads, with an emphasis on the

²For a review of the Brady Plan, see ANDIMA: Relatório Econômico, 1995.

³See the J. P. Morgan Research Reports of 1995 and 1999 listed in the References.

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OAS and its dynamics. We focus our analysis on the importance of the OAS and its volatility on risk management and stress testing. Moreover, our analysis shows that the proper valuation and risk management of these securities requires the consideration of the pair (OAS, Vol (OAS)), instead of the usual consideration of the OAS alone as a suficient risk statistic. In other words, the risk profile of these securities can not be precisely characterized by the size of the OAS alone, which can be high at times of crises, but also by the consideration of its complex dynamics, given by the spread volatility. Section V concludes the paper.

2. Main Sources of Risk.

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Brady bonds are usually traded with a discount when compared with US Treasury securities because they posses substantially more risk. That risk comes from several sources. Beyond all these risks we can emphasize *default*, *liquidity* and *volatility* risk.

Brady bonds most well known source of risk is the *default* risk. Since Brady bonds were issued by highly indebted countries, their coupon payments might not be considered as a certainty. These bonds are then traded substantially below their par values with an usually large spread-over-Treasury. The difference between the bond market price and its par value represents the likelihood the market associates to the honoring of these debts. This spread-over-Treasury represents the "price of default". With the magnitude of the spread it is possible to determine the implied probability of default the market is associating with the Brady price. In this paper, we use a simple technique described in Bhanot (1998) to determine default probabilities using the US rates term structure and a recovery factor. This recovery factor represents the residual value of the bond, if the country misses a payment. There were countries

that actually suspended their interest rate payments: Brazil, in 1987 and most recently, Russia in 1998, Equator in 1999 and Argentina in 2001. The residual value of these bonds has varied from 15% to 60% of par value.

A second source of risk for Brady bonds is *liquidity risk*. These securities are traded over the counter trough broker dealers or market makers. Since they are a product of a renegotiation and rescheduling of old debts, there are many types of Brady bonds, each of them with its own terms and issue amount. Some Brady bonds issue amounts are so small or so concentrated in a specific bank portfolio that they are usually unavailable for trading (i.e. there are no quotes on a dealer's bid/offer screen). In stress periods, even in the case of the more liquid bonds, the spread between bid and ask quotes increases substantially and sometimes a price is not available. During such periods, it is difficult to manage repurchase agreements (repo) and reverse repurchase agreements (reverse-repo) contracts (that are used to leverage a portfolio). This is explained by the occurrence of many margin calls and changes in repo and reverse-repo interest rates depending upon the demand of the specific Brady bond booked on the portfolio. Another problem is the change on the "haircut" value during crisis periods. When a bond is bought, part of the money is borrowed from a bank, using a repo contract. The bond remains as a guarantee of this lending. The "haircut" is the rate between the money borrowed and the total value of the bond. It represents the rate of leverage of a portfolio. This "haircut" depends upon how interested is the market maker on borrowing or lending money, taking Brady bonds as guarantees. It also depends upon the Brady bond market demand and price. Before the Russian crisis in 1998 the normal haircut was between 95% and 90%. During the crisis these values were reduced to 60% and 50%depending upon the bond. Even if a portfolio has an almost

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perfect hedge to any variation on bond price and interest rates values (on a relative value investment, for example), during a stress period, the prices may diverge, if some of these securities are unavailable for trading. Moreover, it may occur some margin calls led by prices or haircuts changes. These calls may obligate the closing of some positions in an unfavorable situation. Depending on how stressed is the market, these margin calls, added to some incapacity of buying or selling some securities for its low liquidity during these periods, could substantially reduce the net asset value of a portfolio.

A third source of risk of Brady bonds is the *volatility risk*. Brady bonds are very volatile when compared with developed countries government bonds or high quality corporate securities. This happens because Brady bonds prices depend on political and economic factors of an emerging market country and its relations with the rest of the world. It depends also on the instantaneous market expectations about emerging markets and high yield bonds. These conditions change substantially trough time, leading to a constant fluctuation of these prices. Moreover, Brady bond investors usually invest across several emerging markets countries at the same time, and then if some stress occurs in any of these markets, such as default of one specific bond, the whole Brady bond market is affected because investors have to withdraw investments in several other countries bonds to supply margin calls and losses in the defaulted bond. This kind of market behavior makes the Brady bond market very volatile and risky because bond prices have sensitivity to almost every local crisis in the world⁴. At those periods, Brady bond price volatility is comparable even with equity markets volatility. As we will show below, when analyzing Brady bonds, it is necessary to observe not only the instantaneous price or

 $^{^{4}}$ See also Schleifer and Vishny (1997) for a study on convergence trades and spreads for bonds and fixed-income securities.

spread, but also its volatility. The spread fluctuates substantially through time, very frequently on a larger magnitude than the price itself. Once most of Brady bonds also have embedded options, the proper spread to observe is the Option Adjusted Spread (OAS). The dynamics of the OAS, which can be characterized by its volatility, is also to be considered. Because spread volatility is large, it is also necessary to understand the OAS not as a stable value, but as a number that fluctuates through time. This indicates that the option value is also variable.

In the next section we will explain the pricing model used to determine the OAS of Brady bonds. We will also describe the Brady bonds used in this paper and explain the influence of the options and the OAS on risk management and stress testing.

3. The Option Adjusted Spread.

The proper determination of the OAS requires an interest rate derivatives pricing model. The interest rate dynamics analyzed is the dynamics of the US Treasury securities, the underlying stochastic variable in the computation of the embedded options. There are several interest rate derivatives pricing models available in the literature: Vasicek (1977), Cox, Ingersoll and Ross (1985), Hull and White (1990), Jamshidian (1991), Heath, Jarrow and Morton (1992) and Duffie and Kan (1995). All these models, either by arbitrage or general equilibrium conditions, derive valuation equations for the interest rate term structure and for dependent derivative securities.

Since the study of the OAS dynamics involves the pricing of embedded options, it is necessary to use a model compatible with the observed US term structure. This is because some models, such as Cox, Ingersoll and Ross (1985) and Vasicek (1977), endogenously derive an analytical term structure that does not necessarily match the term structure observed in the

market, which is a requirement for the correct pricing of interest rate dependent options, as it is the case of the embedded options of the Brady bond securities. Therefore we will use a model that belongs to the Heath, Jarrow, Morton (1992) (HJM) framework that explicitly takes into account the market interest rates. The original HJM model has the advantage of allowing the consideration of a general term structure of volatility (TSV), but this usually requires the implementation of a non-recombining (non-Markov) pricing tree. To correctly model Brady bonds on a binomial tree, there should be at least one interval *per* coupon payment day, since there are embedded options exercise dates at these points. Using the general HJM model, there will be at the end of the binomial tree at least 2^n states of nature, where n is the number of coupon dates until the Brady maturity. Since there are Bradies with more then 50 coupon payments until that date, it is not computationally feasible to use this model to calculate the bond value.

Therefore, we need a version of the HJM model that allows a simple recombining tree structure⁵. The simplest model is the Gaussian interest rate model, developed independently by Hull and White (1990), Jamshidian (1991), and Heath, Jarrow and Morton (1992) as an extension of Vasicek (1977). In the Gaussian interest rate model, there is a closed form solution for the term structure of volatility given by:

$$\sigma\left(t,T\right) = \sigma \times e^{-a(T-t)}$$

Where a is the speed of mean reversion and σ is the volatility parameter of the instantaneous interest rate.

In that special case, the non-recombining binomial tree converges to a Markovian recombining tree that makes possible the

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 $^{{}^{5}}$ See Aït-Sahalia (1995) for an analysis of the several models for interest rate dynamics available in the literature.

analysis of Brady bonds, since the number of states of nature in that tree grows at a linear rate.

Indeed, it is possible to derive the analytical term structure in any given future date t, based on the original observed term structure and the value of the instantaneous spot interest rate r^* . In this case the entire set of forward rates can be recovered. In particular:

$$f(t,T) = f(0,T) + e^{\kappa(T-t)} [r(t) - f(0,t) - \beta(t,T)\phi(t)]$$

Where:

$$\beta(t,T) = \frac{1}{\kappa} \left[1 - e^{-\kappa(T-t)} \right]$$
$$\phi(t) = \frac{\sigma^2}{2\kappa} \left[1 - e^{-2\kappa t} \right]$$

We can also describe the equation above in terms of "pure discount bonds" (PDBs) like:

$$P(t,T) = \frac{P(0,T)}{P(0,t)} \times e^{-\beta(t,T)[r(t)-f(0,t)] - \beta^2(t,T)\phi(t)/2}$$

Moreover, for the exponentially dampened volatility structure, the exact dynamics of the spot rate can be established. In particular, it can be shown that the instantaneous spot rate dynamics is given by:

$$dr = \left(\theta(t) - ar\right)dt + \sigma dZ$$

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^{*}See for instance, Ritchken (1996).

Where r is the instantaneous spot interest rate, $\theta(t)$ is a time-dependent long-term rate (to where the spot rate is converging) and dZ is a Brownian motion.

Given the closed form solution for the TSV and an estimation of the TSV for the US Treasury rates (observed), it is possible to estimate the parameters, volatility (σ) and speed of mean reversion (a) using non-linear-least-squares as described in Gonçalves and Issler (1996). We will present our estimation results for these parameters through time in the next section⁷.

In this paper we will analyze Brady bonds selected from Brazil, Argentina, Mexico, Poland, Bulgaria and the Philippines. We try to focus our analysis in the same type of bonds for all these countries so it will be possible to compare the results obtained. When Brady bonds were issued, each country had its international debt restructured based on a negotiation with their lenders and the IMF. Each case was studied apart from the others.

Thus, there are several types of Brady bonds in the market today. Two types are most common and almost every country that took part on the Brady plan has at least one. They are the *Par bond* and the *Discount bond*. The *Par bonds* received this name because they were issued at par (or at the original value of the sovereign loan). These are bullet bonds that have a fixed rate semi-annual coupon that changes (increases) through time. Their initial maturity is of 30 years. The Par bonds have rolling interest guarantees from 12 to 18 months (2 to 3 coupon payments until maturity). They also have a principal guarantee collateralized by U.S. Treasury zero coupon bonds. The *Discount bonds* are named this way because they were issued at discount (under its original face value of sovereign loan).

 $^{^7 \}rm See$ also Amin and Morton (1993) and Bliss and Ritchken (1996) for alternative empirical studies of the term structure of volatility.

These are bullet bonds paying a floating rate semi-annual LI-BOR market coupon (added to a small portion fixed). Their initial maturity is also of 30 years. The Discount bonds also have rolling interest guarantees from 12 to 18 months (2 to 3 coupon payments until maturity and principal guarantee collateralized by U.S. Treasury zero coupon bonds). Both Par and Discount bonds have embedded call options belonging to the issuer (almost every Brady was issued with these embedded options). These bonds are callable at par on coupon dates if there was no default. Table I below presents the main characteristics of the bonds we will analyze in the next section:

Country	Bond type	Issue Date	Maturity	Issue	Coupon type
Issuer			Date	Amount	
				(USD millio	ons)
Brazil	PAR	15/04/1994	15/04/2024	10,489	Fixed-(4to 6%)
Brazil	DISCOUNT	15/04/1994	15/04/2024	7,286	$\mathrm{Libor}{+}.8125\%$
Poland	PAR	27/10/1994	27/10/2024	930	Fixed-(3to5%)
Poland	DISCOUNT	27/10/1994	27/10/2024	$2,\!970$	$\mathrm{Libor}{+}.8125\%$
Mexico	PAR	28/03/1990	31/12/2019	17,875	Fixed-(6.25%)
Mexico	DISCOUNT	28/03/1990	31/12/2019	11,507	Libor+.8125%
Argentin	a PAR	30/09/1993	31/03/2023	$12,\!489$	Fixed-(4to6%)
Argentin	a DISCOUNT	31/03/1993	31/03/2023	4,136	$\mathrm{Libor}{+}.8125\%$
Philippin	ies PAR	01/12/1992	01/06/2018	$1,\!894$	Fixed
					-(4.25to6.25%)
Bulgaria	DISCOUNT	28/07/2094	28/07/2024	1,850	$\mathrm{Libor}{+}.8125\%$

Table I: Main characteristics of the Brady bonds consideredin the study of the dynamics of the OAS

We also select Par and Discount bonds because of their guarantees. As we will show below, the presence of these guarantees increases the value of the embedded options, highlighting

the necessity of taking them into account when computing the portfolio risk. Moreover, the influence of the embedded options was more important in the case of fixed rate coupon bonds than in floating coupon bonds. That happens because we model the behavior of the LIBOR as a function of the U.S. Treasury zero coupon bonds. Thus, if the US Treasury term structure moves down, the coupon rates also decrease. Therefore, the price of a floating coupon bond does not modify significantly, remaining under par in a situation where the options are not exercised. On the other hand, in the case of a fixed rate coupon bond, the market value of the bond increases when the US Treasury term structure moves down, so depending upon how low US rates are, the bond can reach values over par. In this situation the options would be exercised.

If the embedded options are not considered when computing the portfolio risk, large hedge differences in the portfolio may occur, leading to unexpected losses. Moreover, in a stress situation where large price movements (up or down) occurs, the lack of consideration of the embedded options may be very dangerous for the portfolio since the option effect on price is non-linear, especially for the at-the-money case.

4. Statistical Analysis of Spreads.

Our statistical analysis will be centered on a time-series study of the OAS of the Brady bonds securities of Brazil, Argentina, Mexico, Poland, Bulgaria and the Philippines. Obtaining the OAS requires the estimation of the parameters of the TSV of the US Treasury term structure of interest rates.

The parameter estimation is made using a methodology described in Gonçalves and Issler (1996). The methodology is as follows: first we estimate the observed TSV based on weekly observations of US Treasury term structure of interest rates for several periods using a conditional method. Then we estimate

the theoretical TSV parameters of the Gaussian interest rate model using a non-linear least squares method.

We performed this analysis for several periods, aiming to detect the stability of these parameters through time. When performing the estimation we used a weekly based data set. The results are listed on Tables II and III bellow:

End	24/04/2000	18/10/1999	05/04/1999	28/09/1998	16/03/1998	02/09/1997
18/10/199	9 0.0116					
B 05/04/199	9 0.0125	0.0118				
E 28/09/199	8 0.0145	0.0136	0.0128			
G 16/03/199	08 0.0160	0.0158	0.0170	0.0106		
I 02/09/199	07 0.0163	0.0162	0.0171	0.0154	0.0131	
N 03/03/199	07 0.0158	0.0155	0.0158	0.0141	0.0121	0.0117

Table II: Estimated instantaneous interest rate volatility parameter (σ) based on US term structure data

End	24/04/2000	18/10/1999	05/04/1999	28/09/1998	16/03/1998	02/09/1997
18/10/199	99 0.0035					
B 05/04/199	99 0.0095	0.0204				
E 28/09/199	08 0.0137	0.0158	0.0180			
G 16/03/199	98 0.0164	0.0184	0.0220	0.0281		
I 02/09/199	97 0.0185	0.0218	0.0240	0.0323	0.0286	
N 03/03/199	97 0.0161	0.0191	0.0204	0.0256	0.0203	0.0073

Table III: Estimated instantaneous interest rate speed of mean reversion parameter (a) based on US term structure data

On the first column of the table we placed the initial date of the estimation and on the first line the final date of the estimation. Inside the matrix we placed the referred period estimated

parameters. The objective of these sampling windows was to see how the US TSV parameters vary through time. As we can verify, the volatility parameter, in the case of the six months estimation (main diagonal values) stays on 0.0119 or 1.19% per year. For longer horizon estimations, from 1 year to 3 years, the mean volatility parameter is 0.016 or 1.6%. These estimated values indicate that, in long horizon periods, the US term structure has a greater volatility than on short ones. However, when we study the estimated values for the speed of mean reversion parameter to the periods considered, we could not observe any common pattern. For the six months estimation periods this parameter also change substantially, but staying within higher values.

Since we will study the time-series properties for the period from January of 1998 until May of 2000, we decided to use the 3 years period estimated parameters. These parameters values are: volatility parameter (σ) – 0.0158, speed of mean reversion parameter (a) – 0.0161. We used the parameters described above in the estimation of the Brady bonds OAS. We also calculate the value of the static spread for comparison. Figures 1 to 10 below, show the value of the spreads with and without embedded options for the period and bonds considered.

Figure 1: Spreads with and without embedded options for the PAR bond of Brazil

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Figure 2: Spreads with and without embedded options for the PAR bond of Poland

Figure 3: Spreads with and without embedded options for the PAR bond of the Philippines

Figure 4: Spreads with and without embedded options for the PAR bond of Mexico

Figure 5: Spreads with and without embedded options for the PAR bond of Argentina

Figure 6: Spreads with and without embedded options for the Discount bond of Brazil

Figure 7: Spreads with and without embedded options for the Discount bond of Poland

Figure 8: Spreads with and without embedded options for the Discount bond of Bulgaria

Figure 9: Spreads with and without embedded options for the Discount bond of Mexico

Figure 10: Spreads with and without embedded options for the Discount bond of Argentina

As the OAS and static spread time series showed in the figures above, the OAS is always smaller than the static spread for the securities considered. This is because Brady bonds only have embedded call options that belongs to the issuer, which reduces the security value to the bondholder. Thus, to have the same market price, the dynamic spread has to be smaller in magnitude than the static one. We also observe that the spread and the OAS changes substantially through time for all analyzed bonds. In particular, for the periods of Russian and Brazilian financial crisis of 1998 and 1999 respectively.

In Table IV, we divide the spreads into four sub-periods and analyze them separately. There we show, for each period studied, the values of the static spread, OAS, the difference between them and also the static spread and OAS volatilities. Observing these values, we noticed that the difference between the OAS and the static spread is larger in the case of the PAR bonds than in the case of the Discount bonds. This is because PAR bonds pays pre-fixed rate coupons and have a greater chance of having their embedded options exercised. On the other hand, in the case of discount bonds, the coupons are determined by the LIBOR value. Their prices are then less affected by the embedded options, being the mean difference between OAS and static spread smaller than in the PAR case.

On 75% of the analyzed cases the static spread volatility was greater than the OAS volatility. In the specific case of Brazilian and Argentinean Brady bonds, both Par and discount, on every period studied, this fact has occurred. On the Polish bonds case, the PAR bond had a static spread volatility larger than the OAS volatility. On the other hand, for the Polish discount bond, the opposite happened. On the Mexican (Par and Discount) bonds case, the direction of the difference was undetermined. For this particular case, approximately half the time pointed to a greater OAS volatility and the other half to a greater static spread volatility.

In Figure 11 below, we show the Mexico Par OAS and static spread volatilities (calculated based on a rolling 30 trading days standard deviation) behavior through time. We highlight into gray the periods were the OAS volatility is *greater* than the static spread volatility. The relation between OAS and static spreads volatilities changes several times along the analyzed period. These results show how *non-linear* is the effect of the options in the volatility of the spread.

Figure 11: Comparison of the static and dynamic spreads volatilities for the Mexican PAR bond, showing the periods when the dynamic spread (OAS) volatility is larger than the static case

Also based on the results of Table IV, we observe that the larger the spread is, the more likely is the static spread volatility to be larger than the OAS volatility. That happens because the smaller the spread, the more effective (more at-the-money) become the embedded options and more non-linear are their effects on the OAS calculation. This also affects the volatility of its value.

We also observe that Brady bond volatility is not only very

large but also varies substantially through time. That variation shows the importance of taking into consideration not only the spread or even the OAS when analyzing a Brady bond. It is also necessary to take into consideration the fact that the static spread and, mainly, the OAS of Brady bonds changes through time when calculating their risk. Taking into consideration the OAS dynamics is also very important. Depending on the value of the bond, the OAS volatility can be even greater than the spread volatility because the option effect is non-linear leading to the magnification of risk⁸.

As a summary of these results, we propose as a central contribution of this paper, that the proper metric for evaluating the risk and value of a Brady bond security to be the pair (OAS, Vol (OAS)), instead of the usual OAS.

A natural extension of the above analysis of Brady bonds spreads is the calculation of the implied probability of default of these bonds. This probability represents numerically the likelihood the market associates with the payment of the coupons of the bond. We determine these values using a simple technique described in Bhanot (1998). To estimate these probabilities we had to use the US observed term structure and a recovery factor, which represents the residual value of the bond, if the country misses a payment. We use in our estimation a recovery factor of 40% that was the residual value of Brazilian bonds when Brazil missed a payment in February 1987. The figure below shows a time-series of the implied probability of default of the Mexico Par bond:

⁸See also Boudoukh, Richardson and Whitelaw (1996) for an empirical analysis of Brady bonds market risk and Gonçalves and Barros (1998) for an analysis of the OAS of Brazilian eurobonds.

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Figure 12: Default probabilities implied on bond prices – Mexico PAR bond

5. Conclusions.

In this paper, we associate Brady bond securities with three major sources of risk: default, liquidity and volatility. In a static scenario the risk of these securities can be expressed as a spread-over-treasury value. Once Brady bonds have embedded options, it is necessary to consider the dynamics of the US treasury curve and to calculate the OAS value instead of the static spread value.

Brady bonds prices are very volatile because they depend on the expectation of payment of the coupons, which is linked with political and economic factors of an emerging market country and its relations with the rest of the world. That uncertainty makes also the spread and the OAS very unstable and volatile. In a Brady bond risk analysis it is necessary to focus the attention not only on the spread magnitude, but also its volatility. As the results of our research indicate, the proper pricing and risk management of these securities are given by the pair:

(OAS, OAS Volatility)

Our empirical analysis demonstrates that Brady bonds OAS and spread volatilities changes substantially along time reflecting calm and nervous periods. The proper consideration of this

volatility may be even more important than the magnitude of the spread itself.

The consideration of embedded options also has a significant importance when analyzing the volatility because, depending on the condition, the OAS volatility can be either greater or smaller than the static spread volatility. The lack of consideration of any of these factors can cause an inadequate evaluation of Brady bonds risk and lead to errors in the determination of immunization portfolios, which can take the investor to severe and unexpected losses.

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