Hedging Emerging Market Debt: an Example of Mexican Brady Bonds

Nazibrola Lordkipanidze

and

Glenn C.W. Ames

Abstract

Brady Bonds are exposed to two different types of risk: sovereign risk and the U.S. interest rate risk. Methods of minimizing the Mexican Par Brady bond exposure to the U.S. interest rate risk were analyzed in this study. Hedging models were developed using two approaches: (1) the regression and approach and (2) the duration approach. The conditional hedge ratio model, accounting to all available information, results in the best minimum-variance hedge ratios. Periodic rebalancing of the futures position as well as selecting an appropriate rollover procedure are important for maximizing the performance of the hedge.

INDEX WORDS: Brady bonds, Hedging, Interest Rate Risk

Hedging Emerging Market Debt: An Example of Mexican Brady Bonds

Introduction

In the last two decades the globalization of trade and finance has led to increased integration of capital markets in developed and developing countries. The emergence of new markets in Eastern Europe, Latin America, Asia, the Mideast, and Africa opened up attractive opportunities for investors searching for the highest returns. Emerging bond markets appear to be an attractive option for two reasons. They offer higher margins over U.S. Treasuries because of their weaker credit rating and they also offer the possibility of capital gains as developing economies recover rapidly. This improves investor perception of market conditions in these regions.

The success story of the decade, so far, has been Latin-American Brady bonds, sovereign bonds that allow developing nations to restructure their external debt into long-term bonds with fixed interest rates. They are considered to be the most active emerging market investment instruments. The face value of Brady bonds currently outstanding is more than $140 billion, with bonds issued by Mexico, Argentina and Venezuela accounting for about 85 percent of the total (Chicago Mercantile Exchange 1996, p. I 1).

Terms for individual Brady packages vary with respect to the maturity, fixed or floating coupons, amortization schedules, and the degree to which principal and interest are collateralized. Par and discount bonds account for the majority of the Brady bonds. They are dollar-denominated, with their principal backed by zero-coupon U.S. Treasury bonds. In contrast to Mexican par and discount bonds, Argentine, Brazilian and other Brady bonds are not collateralized. The price of these uncollateralized bonds reflects the market's opinion of the present value of a stream of risky sovereign payments to be made over the life of the bond. Latin-American Brady bonds carry very long maturities of 25 and 30 years. Because they are more liquid than other Latin American debt issues, Brady bonds tend to be the region's most volatile bonds. A complex combination of factors, both internal and external to the region, have been affecting the performance of Brady bonds.

Objectives of this study are: (1) to analyze the risk inherent in Mexican Brady bonds and (2) to develop a cross hedging model for risk management in Mexican Brady bonds.

U.S. Interest Rate and Sovereign Credit Risk of Brady Bonds

Par and Discount Brady bonds are exposed to two different kinds of risk: U.S. interest rate risk and sovereign credit risk. U.S. interest rate risk of a Brady bond originates from its dollar denominated collateral. When a coupon is paid, the collateral associated with the coupon rolls forward. The value of this collateral rises and falls with the Treasury bond market. When the American bond prices rally, as it happened for much of 1995, Brady bond prices soar. When Treasuries fall, as they did in February 1994, Brady bonds fall.

Sovereign credit risk of Brady bonds arises from the internal factors of the issuing country such as political and economic stability. In 1994, prices collapsed after Mexico's financial crisis. The ensuing crisis in the economy shocked emerging market investors to such an extent that the flow of capital from developed economies into emerging markets slowed significantly during the following year (Morse 1995, p. 6).

The exposure to sovereign risk is what motivates the investment in the first place. As with other emerging debt issues, one reason for investing in Mexican Brady bonds is the expectation that the country's creditworthiness will improve. As that happens, with all other factors held constant, the spreads of Brady yields over Treasury yields narrow (CBOT and K.

J. Telljohann, 1994). The long term outlook for Brady bonds and other Mexican equities remains optimistic due to solid domestic fundamentals. However, given the increasing dependence of emerging markets on flows of U.S. investment, it is important that Brady bond investors protect their positions from U.S. interest rate risk. The hybrid nature of Par and Discount Mexican Brady bonds allows investors to use Treasury futures and options to hedge out the U.S. interest rate risk.

Literature Review

Anderson and Danthine (1981) provided a theoretical description of hedging in futures markets that accounts for a broad class of agents. Cash and futures contracts are rarely perfect substitutes. Practically any risk-reducing investment on the futures market can be interpreted as a cross-hedge. The rarity of a perfect hedge may justify a portfolio approach to hedging, whereby risk reduction is achieved through dealing in multiple contracts.

The conventional approach used by many researchers in estimating the optimal hedge ratio is to use OLS estimation of the slope coefficient in a simple regression framework. The question of whether price levels, first differences, or returns could be used in the simple regression approach has become controversial (Brown, 1985; Myers and Thompson, 1989).

Myers and Thompson (1989) derived a generalized approach and showed that all of the simple regression approaches using price levels, price changes or returns are special cases of the generalized approach, and they are only appropriate under special circumstances. They indicated that the slope parameters from simple regressions give only the ratios of the unconditional covariance and variances between the dependent and explanatory variables.

However, the covariance and variance in the optimal hedging rule are conditional moments and depend on information available at the time that the hedging decision is made.

The regression-based approach is the most popular and the most widely used. However, this approach has been criticized in the literature for having numerous theoretical and statistical problems (See Halliard, 1984; Bell and Krasker, 1986; Myers and Thompson, 1989).

Another broad approach to determining the most effective hedge ratio is the duration approach. The optimal hedge ratio is chosen to equal the ratio of the duration of the spot asset to the duration of the futures contract. If the duration of these assets is known with certainty, then a hedged portfolio with zero duration or interest rate risk can be easily developed. Gay and Kolb (1983), Figlewski, Koze and Merrick (1986), and Kawaller (1992) discussed this approach.

Kawaller (1992) pointed out several deficiencies of the regression-based minimum-variance hedge ratio and demonstrated that the results of this method are path-dependent; that is, the effective rate ultimately realized depends on whether rates rise or fall during the hedge period. Unlike the minimum-variance approach, the duration-based hedge ratio results in an *ex post* effective rate that is independent of the direction the market rate moves over the hedge period.

Indicating that a portfolio hedging model has several drawbacks, Gay and Kolb (1983), proposed the price sensitivity (PS) model. The basic strategy of this model is based on duration of the bond and the futures to choose the number of futures contracts to hedge one unit of a bond with the goal that over the life of the hedge, the hedger's overall wealth is unchanged. Gay and Kolb emphasized that a PS hedging model is able to capture the key factors necessary to effectively control interest rate risk. These factors are: 1) the maturity of the hedged and hedging instrument; 2) the coupon structure of the hedged and hedging instruments; 3) the length of time the hedge will be in effect; 4) the risk structure of interest rates; and 5) the term structure of interest rates mentioned above.

Pitts (1985) and Clayton and Navratil (1985) criticized the PS strategy. They pointed out that the models of portfolio theory are expectational models and imply that historic relationships will continue or that they are the best estimate of future price relationships. Therefore, current risk and term structure of rates are implied from past relationships and are considered in forming hedge ratios.

The Minimum-Risk Hedging Framework

The portfolio approach to hedging assumes that the primary motivation for hedging is risk reduction. The objective of a Brady bond investor is to minimize his exposure to the U.S. interest rate risk by hedging an existing cash position with an offsetting position in Treasury bond futures. Spot and futures positions may be analyzed as a portfolio of two securities. The number of futures contracts sold per unit of the cash portfolio is a hedge ratio. If the hedge ratio is not properly determined, a decrease in the value of the cash portfolio will not be completely offset by an increase in the value of the futures contracts.

Movements of Brady bonds and CBOT Treasury bond prices for the period from January 1991 to September 1995 are shown in Figure 1. The figure illustrates that Par Brady bond price movements are highly correlated with T-bond futures price movements for the entire period. Since Brady bonds are exposed not only to the U.S. interest rate risk, but also to sovereign risk, Brady bond spot and Treasury bond futures prices do not move exactly in tandem. Therefore, it is rational to have a hedge ratio less than one. Other things being equal, the more volatile the U.S. interest risk exposure is, the larger the hedger's futures position should be.

Since Brady Bonds have a longer maturity (30 years) than Treasury Bond Futures (2 years), hedgers need to extend the effective maturity of an entire hedge period further out than the availability of futures contracts. This can be done by rolling forward the expiring contracts into new contracts as they become available. The artificial price history can be created by linking the price series of the futures contracts through the time of a hedge. A three month rollover procedure utilized in this research, links the closing prices of the nearest to expiration futures contracts beginning three months before delivery and ending at the beginning of the delivery month. The procedure excludes the delivery months of the contracts to avoid unusual market activities near maturity. Figure 1 shows that the entire artificial time series does not exhibit significant price jumps, and therefore, an adjustment of price levels upon rollover does not appear necessary.

In this analysis 21 different Treasury bond futures contracts are used to construct an artificial price series for the period from January 1991 to September 1995. Data on the prices, yields to maturity, and stripped yields of Mexican Brady bonds for the period from January 1991 to September 1995 were provided by Solomon Brothers, Inc. Treasury bond futures prices were recorded from the CBOT CD-Rom Data Base.

Regression Approach

If the joint probability distribution for Brady bond and Treasury futures prices were known, the appropriate hedge ratio could be determined accurately. However, this is not the

$$\triangle P_t = a + b^* \triangle f_t + \epsilon_t \qquad (1)$$

case in practice and the problem is to estimate hedge ratios from historical data. The simple (unconditional) regression model for estimating the optimal hedge ratio is specified as follows:

where Δp_g and Δf_t are either daily price changes or daily returns (percentage changes in price from one time period to the next) of cash and futures instruments respectively, and

$$b^* = \frac{cov(\Delta P_t, \Delta f_t)}{var(\Delta f_t)} \qquad (2)$$

is the ratio of the number of the units of futures to the number of the units of the spot position which must be assumed in order to offset the variance of the spot market.

Bell and Krasker (1986) proved that the regression model will give the true minimum variance hedge-ratio only if b^*, $E(\Delta P_t)$ and $E(\Delta f_t)$ are conditional on information φ_{t-1} available at time t-1. For simplicity we assume that the only variables that give information about the hedge ratio at time t are P_{t-1}, and f_{t-1}, , and that the regression coefficients α and β are linear functions of these variables.

A conditional least squares model is specified as

$$\Delta P_t = (\alpha_0 + \alpha_1 P_{t-1} + \alpha_2 f_{t-1}) + (\beta_0 + \beta_1 P_{t-1}) + \beta_2 f_{t-1})\Delta f_t + \epsilon_t \qquad (3)$$

where the slope coefficient

$$\beta_0 + \beta_1 P_{t-1} + \beta_2 f_{t-1} = HR^* \qquad (4)$$

is taken as the hedge ratio. Thus, the optimal hedge ratio is not a constant value but it varies for each period *t*, and is dependent on the spot and futures price changes.

The optimal hedge ratios were estimated using both conditional and unconditional regression models using regressions for price changes and returns. The iterative Prais-Winston GLS procedure was used for the estimation to account for autocorrelation. The estimates of the unconditional hedge ratio β^* and the coefficients β_0, β_1, β_2, for computing the conditional hedge ratio, standard errors of the estimates, and the mean values of hedge ratios for the entire estimation period are presented in Table 1.

To test the conditional hedge ratio for constancy, F-statistics were computed for the restriction $\beta_1 + \beta_2 = 0$. The results of the test indicate that the coefficients β_1, β_2, are significantly different from zero for both price change and returns regressions (Table 1). Thus, the optimal hedge ratio varies in time and is conditional on the information available at the time hedging decision is made.

Duration Approach

The duration of a security is a fundamental concept, indicating how much the price of an asset will change in response to a given change in the yield to maturity. The relative change in the value of a cash security to that of futures contracts can be indicated by the respective durations given a single yield change applicable to both assets. For bonds and bond futures contracts, the optimal hedge ratio can be estimated using the Price Sensitivity Formula:

$$HR^{*} = -\frac{DUR_S}{DUR_f}\frac{S(1+y_f)}{f(1+y_s)} \qquad (5)$$

where DUR_s and DUR_f = the modified durations, S and f = the prices, and y_f and y_s = the implied yields of the bond and the bond futures, respectively.

The Price Sensitivity formula accounts for a coupon, yield, and maturity effects, along with changes in the term structure. It incorporates information from current prices rather than regressing past spot prices on past futures prices.

The unique structure of Brady bonds, combining U.S. interest rate and sovereign risk, allows a modification of the Price Sensitivity formula. The underlying assumption is that the stripped yield of a Brady par issue is a better measure of the sovereign component of the bond's risk then the yield to maturity. If the U.S. interest rate changes while sovereign credit risk remains constant, the differential of the U.S. Treasury yield and the stripped yield, called "stripped yield spread", should remain constant. The stripped yield allows hedgers to adjust the duration measure so that they can more precisely account for changing U.S. interest rate risk.

Substituting bond yield, ys, with stripped yield, y_{STR}, and modified duration, DUR_s, with adjusted modified duration, DUR_{MOD}, gives

$$HR^* = -\frac{DUR_{MOD}}{DUR_f}\frac{S(1+y_f)}{f(1+y_{STR})} \qquad (6)$$

Thus, the method of hedging out the U.S. interest rate component of Brady bonds risk and determining the most effective hedge ratio depends upon expectations about the future spread relationship between the Brady bond market and the Treasury market. If the hedger assumes that stripped yield accurately measures the issuing country's creditworthiness, then adjusted modified duration should be used in the Price Sensitivity formula. If the hedger instead assumes that the appropriate measure is the yield-to-maturity, then the traditional Price Sensitivity formula should be used to determine the minimum variance hedge ratio. However, if the investor assumes stripped yield spreads will not move independently of Treasury yields over the term of investment, that is the spreads may be functions of the interest rates, as well as functions of creditworthiness, then the regression method is an appropriate tool for determining hedge ratios.

Simulation of Hedging Scenarios

In the previous sections several models were considered to be appropriate for estimating the minimum variance hedge ratio. Within the regression approach, these models include: (1) the conditional hedge ratio model using daily price changes, (2) the conditional hedge ratio model using daily returns, and within the duration approach, (3) the Price Sensitivity model using the modified duration and yield to maturity, and (4) the Price

Sensitivity model using adjusted modified duration and stripped yield. To compare the effectiveness of the hedges based on these models and to determine which gives the minimum-variance hedge ratio, nine-month duration routine hedges were run for each of the models starting the first business day of each month for the period from January 1991 to September 1995. Within each model, two possible scenarios of hedging were examined; one with periodical rebalancing of the hedge ratio and another without rebalancing. Also, the regression model based on the unconditional hedge ratio was examined. The returns to the portfolio consisting of one Par Brady bond and an appropriate number of Treasury bond futures contracts were generated for the 57 routine hedges using each of the models. The standard deviations of these returns are presented in Table 2.

The results indicate that the periodic rebalancing of the hedge ratio reduced the variance of returns for all of the models, while the constant (unconditional) hedge ratio resulted in the higher variances. The regression model using the daily price changes appeared to be the poorest among all of the models, while the regression model for returns appeared to be the best. The modified duration model resulted in lower variances of returns than the adjusted modified duration. Overall, the regression model using returns resulted in the minimum standard deviation and, thus, appears to be the best for estimating the minimum-variance hedge ratio.

To demonstrate how the hedges would have helped investors during the major market decline of the first half of 1994, the hedge scenario is simulated for the period from October 8, 1993 to August 1994 for each of the models. Assume, that on October 8, 1993, an investor decides to protect his $10 million face value Par Brady bond portfolio from rising US interest rates and establishes an initial position in the nearby CBOT T-bond futures contracts. To avoid the "delivery month complications" the hedger decides to roll the hedge forward to the next contract closest to expiration on the first day of the delivery month. The hedger believes that the optimal hedge ratio needs to be adjusted from time to time. Although the hedge ratios for each trading day can be obtained from both the regression model and Price Sensitivity model, it is not reasonable to assume that the hedger would adjust his position every day since this would be associated with high transaction costs. Instead, the hedger would find it efficient to adjust the number of contracts at the moment of rolling the hedge forward.

The analytical steps of the three month rolling hedge based on the daily returns regression model are illustrated in Table 3. The fact that contracts cannot be sold in portions is ignored for simplicity, and the results are calculated without rounding up the number of contracts. Changes in the portfolio value (total profit/loss) are calculated for the variable hedge ratios with and without periodic adjusting of the hedge ratio. Also, the change in the portfolio value is calculated using a constant hedge ratio based on the unconditional regression model.

This simulation demonstrates, that, for the period from October 8, 1993 to August 1994, the hedge based on the conditional regression model without rebalancing of the hedge ratio appeared to be the most profitable. However, it resulted in a greater change in the portfolio value, although a positive one. The minimum variance was achieved by rebalancing conditional hedge ratios for each rollover period. Therefore, as it was expected, the hedging strategy based on the conditional regression model with periodic rebalancing of the futures position resulted in a minimum change in the portfolio value.

Conclusions

This study was designed to examine methods for minimizing the Mexican Brady bond exposure to the U.S. interest rate risk. The long term outlook for Brady bonds remains optimistic. However, for the most immediate future it is important that investors protect their positions from the negative effects of the U.S. interest rate risk. The substantial correlations between Mexican Par Brady bonds and Treasury bond futures suggests that investors could reduce their portfolio risk by hedging with Treasury bond futures.

The choice of the minimum-variance hedge ratio model depends on investors' assumptions about the nature of yield spreads. Empirical evidence shows that Brady bond stripped yield spreads do not move independently of Treasury yields. Thus, the regression-based approach must be employed to determine the most effective hedge. Within the regression approach only the conditional hedge ratio model, accounting to all available information, results in the minimum-variance hedge ratios. Periodic rebalancing of the futures position as well as selecting an appropriate rollover procedure are important for maximizing the performance of the hedge.

References

Anderson, R. W., and J. Danthine. "Cross-Hedging." Journal of Political Economics. 89(1981):1182-91.

Bell D. E. and W. S. Krasker. "Estimating Hedge Ratios." Financial Management. Summer 1986:3439.

Brown A. "Easing Latin Pain is Our Gain." Orlando Sentinel Tribune. July 14, 1992, p. A8.

Chicago Board of Trade and K. J. Telljohann. "Quantifying and Isolating the U.S. Interest Rate Component of a Brady Par Bond." Chicago, IL: Chicago Board of Trade, 1994.

Chicago Mercantile Exchange. "Brady Bonds." Chicago, IL: Chicago Mercantile Exchange, 1996.

Clayton R. J. and F. J. Navratil. "The Management of Interest Rate Risk: Comment." Journal of Portfolio Management. Summer 1985:64-66.

Figlewski, S., J. Koze, and J. Merrick. Hedging with Financial Futures for Institutional Investors.

Cambridge, Massachusetts, Ballinger Publishing Company, 1996. Gay, G. and R. Kolb. "The Management of Interest Rate Risk." Journal of Portfolio Management.

Hilliard, J. E. "Hedging Interest Rate Risk with Futures Portfolios Under Term Structure Effects." Journal of Finance. 39 (1984):1547-1569.

Kawaller, 1. G. "Choosing the Best Interest Rate Hedge Ratio." Financial Analysts Journal. 8(1992):74-77.

Morse, L. "Survey of Derivatives." The Financial Times. November 16, 1995, p. 6.

Myers, R. and S. Thompson. "Generalized Optimal Hedge Ratio Estimation." American Journal of Agricultural Economics 71 (1989): 858-868.

Pitts, M. "The Management of Interest Rate Risk: Comment." Journal of Portfolio Management. Summer 1985: 67-69.