

Quantitative Portfolio Strategy

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CURRENCY HEDGING IN FIXED INCOME PORTFOLIOS

Introduction

Portfolio managers typically minimize currency exposure in bond portfolios with the use of foreign-exchange forward transactions (forwards). However, the use of forwards cannot entirely eliminate currency volatility, since fluctuations in underlying asset values will lead the portfolio to be either over- or under-hedged. In addition, the use of forwards changes portfolio interest-rate exposures. In this article, we discuss the currency volatility and interest-rate exposures of currency-hedged securities and portfolios and the risk introduced against hedged indices by not replicating index hedges. We also discuss the effect of exchange rate fluctuations on the relative country allocations of portfolios managed against hedged benchmarks. We discuss the methods that investors can use to minimize risk versus hedged benchmarks. Finally, we discuss enhancements that we are making to the analytical information that Lehman Brothers provides for hedged portfolios and indices.

The Interest Rate Exposure in Currency Hedges

The exchange rate at which a forward is struck (forward rate) is the spot exchange rate adjusted for the interest-rate differential between the two currencies (forward points). This is a necessary no-arbitrage condition, illustrated in Figure 1.

In the example in Figure 1, the forward rate is mis-priced, since it does not reflect the interest rate differential between the two currencies, so an investor can buy euros forward too cheaply. As the interest-rate differential between two currencies changes, so does the forward rate, to eliminate arbitrage opportunities.

Consider another investor, who holds a 10-year U.S. Treasury yielding 4.2% and hedges the US\$ exposure into euros with a one-year forward. As the differential between euro and U.S. interest rates fluctuates, so will the pricing of the forward points. This investor is effectively long one-year euro interest rates and short one-year US\$ rates. The currency hedge, therefore, has an effect on the duration exposure of the investor's euro and US\$ portfolios. Accordingly, an investor who chooses a different tenor of hedge from a currency-hedged index is assuming active interest-rate risk.

This example demonstrates another effect of currency hedging on a portfolio. The yield on the portfolio has also changed. Assuming that the forward rate is now correctly priced

Figure 1. **Covered Interest Arbitrage Example**

\$/Euro Spot Rate:	1.10	Today	
\$/Euro 1-Year Forward Rate:	1.08	Borrow 100 Euros for 1 Year at 2%	
		Sell Proceeds for US\$ and Invest at 1%	
		Sell $110 \times (1.01)$ 1 Year Forward	
1 year Deposit Rate		One Year Later	
- Euro	2.00%	Repay Euro Loan	(EUR102)
- US\$	1.00%	Receive Euros from Forward	EUR102.87
		($=110 \times 1.01 / 1.08$)	
		Profit	EUR0.87

and using the same deposit rates, the yield on the hedged 10-year Treasury is now 5.2%, reflecting the interest-rate differential. More generally, the hedged yield on a security can be expressed approximately as follows:

$$\text{Hedged-yield} = \text{Bond yield} + (\text{Base currency interest rate} - \text{Local interest rate}) \quad (1)$$

The duration of a hedged instrument can be expressed approximately as:

$$\text{Hedged-bond duration} = \text{Bond duration} - \text{tenor of bond hedge} \quad (2)$$

The duration decrease in local currency is offset by a corresponding increase in base currency duration.

The Exchange Rate Exposure in Currency Hedges

An investor typically calculates the amount of local currency to be sold forward to hedge a security's foreign exchange exposure in one of two ways. Either the expected future value of the security at the forward date is used, or the current market value of the security is used.¹ Since the end-of-period market value of the security being hedged is not known, unless this period is equal to the security's maturity, this hedge is not perfect (see exception below). If, for example, a euro-based investor hedges a US\$ bond with a market value of \$1,000 through the sale of a forward of equal magnitude and the bond rises to \$1,100, the investor now has an exposure of \$100 to the US\$/euro exchange rate. In practice, many investors periodically re-hedge their portfolios to reduce currency exposures, though as we shall see, this may introduce tracking error versus a hedged index. Investors who use longer tenors for currency hedges without periodical re-hedging will tend to have larger currency exposures and currency return volatilities.²

A foreign security with predictable cash flows may be perfectly currency hedged if the bond is held to maturity and each future cash flow is separately hedged back into base currency. As the example above has shown, since the pricing of the forwards reflects the interest rate differential between the two currencies, this transaction would exchange the interest rate risk of the foreign security for base currency interest rate risk. This would defeat the purpose of owning the foreign security, unless the purpose is to create a new "synthetic" base-currency bond, cheaper than a "conventional" substitute.³

The size of the currency hedge for Lehman Brothers indices is effectively established at the beginning of each month, when the expected future value of all non-base currency exposures is hedged for one month. The index is not re-hedged until the end of the month and, therefore, to the extent that bond markets move away from their expected

¹ Some managers prefer to hedge current rather than future values, entering into currency swaps (a spot purchase and forward sale of currency) when purchasing new securities.

² For example, a euro-based investor hedging the U.S. component of the Lehman Global Aggregate with a 3-month hedge, with no intra-period adjustment, incurred a currency loss equal to 0.11% for the three months ending June 30, 2003.

³ In practice, the arbitrage advantage of a synthetic bond needs to be significant to offset its substantially reduced liquidity.

month-end values, will be exposed in part to currency movements.⁴ The non-deterministic portion of the currency returns for a given country's hedged bond market index is given by:

$$(\text{Local bond market return} - \text{Expected bond market return}) (\text{FX appreciation}) \quad (3)$$

The historical volatility and return of the currency component for a selection of hedged indices are shown in Figure 2b.

This analysis suggests that currency volatility has a limited effect on the overall volatility of currency-hedged indices; nevertheless, it should not be ignored, especially for single-country bond portfolios hedged into the base currency. Furthermore, there is a marked tendency for spikes in bond market volatility to accompany spikes in currency volatility, increasing the overall volatility of currency returns (this can be seen from Equation 3, in which both bracketed terms would increase). For example, in December 2002 and May 2003, a substantial return on the U.S. Aggregate was accompanied by a large fall in the dollar, leading to an average currency loss for euro-hedged investors of 9 bp per month.

Figure 2c suggests that investors who wish to minimize overall portfolio risk should not be overly concerned about the volatility of the hedged currency return. Eliminating currency risk entirely can actually increase portfolio risk, as one source of portfolio diversification (at least at these low effective concentrations) is removed.

The Timing of Currency Hedges

Putting aside those investors who choose to take active currency exposure, investors will incur tracking error versus hedged indices to the extent that hedging methods differ from the treatment of hedges in Lehman Brothers indices. In particular, hedgers may choose

⁴ For more information on index rules for hedged indices, see "Index Rules for Currency Hedging and Currency Returns," *Global Relative Value*, June 9, 2003, Lehman Brothers.

Figure 2. **Volatility of Currency-Hedged Bond Indices**
Three Years Ending June 30, 2003

	Base Currency	Annual Return (%)	Annual Std Dev (%)
2a. Total Return			
Global Aggregate	USD	7.74	2.74
U.S. Aggregate	EUR	10.57	3.23
U.S. Aggregate	JPY	6.72	3.28
2b. Currency Return			
Global Aggregate	USD	0.05	0.05
U.S. Aggregate	EUR	-0.11	0.12
U.S. Aggregate	JPY	-0.02	0.09
2c. Total Return Less Currency Return			
Global Aggregate	USD	7.69	2.73
U.S. Aggregate	EUR	10.69	3.28
U.S. Aggregate	JPY	6.74	3.27

to establish and roll over their hedges at a different time of the month. This may be unavoidable in the middle of the month if the investor establishes a portfolio or receives a large cash flow. Such an investor is now faced with two choices. The most obvious choice is to hedge the current or future expected currency exposure. But the index will itself be partially unhedged, due to bond market fluctuations away from month-end expected values. The currency volatility of the hedged indices given above provides a guide to the potential tracking error such a choice would introduce. Therefore, some investors will prefer the second choice: match the index method and leave part of the currency exposure unhedged. To replicate the index return mid-month, the investor will need to sell the expected forward value of all local currency bonds, computed as at the beginning of the month, for month-end value.⁵ Our analytic systems (detailed below) enable users to obtain these values for each bond, as well as aggregate values for each currency.

The Tenor of Currency Hedges

Some investors choose to use forwards longer (or shorter) than the one-month tenor used by the indices. We have previously examined the implications of selecting alternative hedging tenors in some detail.⁶ We noted that implementing a long-horizon hedging strategy represented a view on the direction of relative interest rates between the hedging and base currencies. Investors face a trade-off between increased tracking error and potential increased return. A longer tenor hedging strategy can, depending on the relative shapes of yield curves, increase carry return relative to a shorter tenor. In addition, such a strategy will lead to modestly reduced transaction costs, as forwards are “rolled” less frequently. An empirical study of various hedging tenors concluded that longer-horizon hedging strategies (up to six months), designed to maximize carry return, have delivered positive information ratios. In this study, we examined the performance of hedging strategies independent from the performance of the underlying bond portfolio. In practice, managers utilizing longer tenor hedges would likely adjust hedges periodically, as movements in bond values create unintended currency exposures.

The Effect of Currency Fluctuations on Index Weights

All Lehman Brothers indices used in the computation of reported returns (the returns universes) are re-constituted every month according to the market capitalization of the underlying securities that compose the index. For global indices, market values are all converted to the base currency. Accordingly, the changes in index country weights from month to month will depend on, among other factors, monthly fluctuations in exchange rates. Country weights for hedged indices are set to be equal to unhedged indices. Therefore, an investor with a perfect index-replicating multi-currency-hedged portfolio will need to make adjustments to country weights at month-end to preserve the integrity of the replication.

For example, following the euro’s 5.4% rise against the dollar in May 2003, the euro component of the Global Aggregate rose by 1.5%. An investor would need to make portfolio adjustments to reflect changes in index composition anyway, due to bonds’

⁵ Ibid. for details of the calculation of the expected forward value.

⁶ “Long-Horizon Currency Hedging in Global Index Portfolios,” *Global Relative Value*, January 7, 2002, Lehman Brothers.

entering and exiting the index, but currency volatility is likely to be the largest contributor to changes in country composition. Figure 3 shows the changes in the currency composition of the Global Aggregate Index for the year to date.

Minimizing the Tracking Error Effect of Currency Exposure for Hedged Indices

We have shown that investors can replicate the currency exposure of hedged bond indices by matching the tenor and timing of currency hedges. A final potential source of tracking error can arise from executing hedging transactions at prices different from those used for index calculations. While these price differences may be small, their large portfolio weight can cause a meaningful performance shortfall. This is especially true for portfolios composed largely of non-base currency bonds. Investors can now use the Lehman Brothers Perfect Index Execution Service, which guarantees execution of one-month hedges at the exact forward rate used for index calculations.⁷

Enhancements to Lehman Analytics for Hedged Portfolios and Indices

Lehman Brothers provides transparent index analytics for hedged and unhedged bond indices. We have recently published information on the calculation of hedged returns for currency-hedged indices and added a new field to index analytics that provides the amount of the hypothetical hedges that are implied in hedged indices.⁸ We will be adding further functionality to analytic systems, which will provide investors with additional information to assist with the replication of currency-hedged indices. New fields will provide the amount of the index hedge in base and local currency, the amount of the effective currency exposure in the index intra-month for each currency, and the unrealized profit/loss on the hedge. Future enhancements will demonstrate the effect of currency-hedging on portfolio and index yields and duration exposures.

Managing and Calculating the Currency Exposure for Hedged Indices

The following provides a practical outline of the steps needed to replicate the performance of currency-hedged indices, including descriptions of fields that will be available shortly in index analytics. Figure 4 provides an example of these calculations.

⁷ See "Index Rules for Currency Hedging and Currency Returns" for further information on the PIE service.

⁸ Ibid.

Figure 3. **Currency Composition of the Lehman Brothers Global Aggregate Index in 2003, %**

	12/31	1/31	2/28	3/31	4/30	5/31	6/30
U.S. Dollar	45.4	44.8	44.7	44.6	44.2	43.1	43.3
Euro	28.4	29.2	29.3	29.4	29.6	31.1	31.0
Japanese Yen	18.5	18.2	18.3	18.3	18.3	17.7	17.7
GB Pound	3.8	3.9	3.7	3.7	3.8	3.8	3.8
Canada Dollar	1.6	1.7	1.7	1.7	1.8	1.9	1.8
Other	2.3	2.3	2.3	2.3	2.3	2.5	2.5

The index is hedged at 4 pm on the last business day of every month, using a one-month forward. The amount of the hedge is given by RUMVHedgeB.⁹ Managers who wish to replicate the index fully will need to replicate the foreign exchange exposure of the index, RUFXExpsr. This arises from the mismatch between the current (local) market value of securities and the expected month-end value (representing the amount of the hedge).

RUMVTotLc is the market value of a bond in local currency, including cash generated from that security during the month.

$$RUMVTotLc = (Price+Accrued Interest) * (RUOutLoc/100) + RUMVCashL$$

RUMVTotal is the market value of a local bond hedged into base currency. This comprises the market value of the security (in base currency terms) and the unrealized profit/loss on the forward foreign exchange contract (the sale of local currency back into base).

⁹ Ibid, for details of the calculation of this value.

Figure 4. **Currency Hedging Example**

Bond

CUSIP: 69352BAC

Index Base Currency: Euros

	Analytics Field	6/30/03	7/17/03
Price		115.623	114.121
Accrued		4.427	0.396
Par Value	RUOutLoc	314,202	295,221
EUR/US\$ - Spot Rate		0.870815	0.894174
EUR/US\$ - Fwd Rate		0.871569	0.894501
Market Value Bonds - Local Currency		377,200	338,078
Market Value Bonds - Base Currency	RUMVSecry	328,471	302,301
Market Value cash - Local Currency	RUMVCashL	0	32,968
Market Value cash - Base Currency	RUMVCash	0	29,479
Market Value Bonds + Cash - Local*		377,200	371,046
Market Value Bonds + Cash - Base		328,471	331,780
Market Value of Hedge			
Fwd sale US\$ - Local	RUMVHedgeB	379,104	379,104
Fwd sale US\$ - Base		(329,913)	(338,886)
Fwd Purchase Euros		329,913	329,913
Profit on Hedge (Base)	RUHedgePL		(8,694)
Total Market Value of Hedged Bond			
Total Value - Local	RUMVTotLc	377,200	371,046
Total value - Base	RUMVTotal	328,471	323,086
Currency Exposure - Local	RUFXExpsr**	(1,905)	(8.058)

* The hedge amount is calculated at the beginning of the month from the expected value of the bond as at month-end. This amount includes any expected security cash flows.

** Since the size of the hedge is based on the month-end expected value of the security, it will be slightly larger than the current market value, creating a small currency exposure.

$$\text{RUMVTotal} = \text{RUMVSecry} + \text{RUMVCash} + \text{RUHedgePL} \text{ (see next)}$$

RUHedgePL is the unrealized profit/loss on the outstanding forward contract. For the returns universe, the size of the forward (in local currency) is computed at the beginning of each month, shown as RUMVHedgeB.

$$\text{RUHedgePL} = \text{RUMVHedgeB} * (\text{Fwd RateEnd}_{\text{local/base}} - \text{Fwd Rate Begin}_{\text{local/base}})$$

$$\text{Rate}_{\text{local/base}} = \text{Number of local currency units per unit of base currency.}$$

RUFXExpr is the amount by which a bond is not fully hedged due to fluctuations in its value (including cash) away from the predicted month-end value. This amount can be aggregated to give the total currency exposure for each index currency.

$$\text{RUFXExpr} = \text{RUMVTotLc} - \text{RUMVHedgeB}$$

Conclusion

It is not possible to eliminate absolute currency volatility entirely from foreign bond portfolios. However, this is neither desirable nor necessary. One can imagine an extreme dynamic hedging strategy in which all currency risk would be eliminated as soon as it arose. Every fluctuation of a bond away from its expected value would give rise to a currency transaction to eliminate the resulting currency risk. Such an exercise would be time consuming and costly and, in our analysis, would increase both absolute and relative volatility. Index replication of currency-hedged indices is possible, given our transparent index methodology and analytic systems. In addition, active managers can use currency hedges as an additional alpha-generation tool, since a hedge has both a yield and a duration effect on portfolio exposures.

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