The Lehman Brothers Swap Indexes

LEV DYNKIN, YURI GREENFIELD, AND DEV JONEJA

LEV DYNKIN
is a managing director, Quantitative Portfolio Strategies, Fixed Income Research, at Lehman Brothers in New York.
ldynkin@lehman.com

YURI GREENFIELD
is a vice president, Derivative Research, at Lehman Brothers in New York.
ygreenfi@lehman.com

DEV JONEJA
is a senior vice president, Derivative Research, at Lehman Brothers in New York.
djoneja@lehman.com

Since the mid-1990s, interest rate swaps have been one of the primary benchmarks for pricing, valuation, and hedging of other fixed-income securities. This is particularly true for investment-grade sectors, such as agencies, mortgages, and investment-grade corporates, which constitute 11.4%, 35.0%, and 26.3%, respectively, of the Lehman U.S. Aggregate Index.

To help investors evaluate, price, and hedge their portfolios, Lehman Brothers is introducing two new families of total return indexes based on swaps. *Bellwether swap indexes* provide total returns of bellwether swaps ranging in maturity from 3 months to 30 years. For example, the ten-year swap index measures the total return of investing in ten-year par swaps over time.

The *swap total return index* is a single performance measure for the swaps market as a whole. This index tracks total returns of an equally weighted portfolio of bellwether swaps with maturities ranging from 1 year to 30 years. The swap index does not include swaps shorter than one year, in accordance with the Lehman index convention that short-maturity instruments are not included in major indexes. The three-month and six-month swap indexes are published separately, and are already used by some investors as a benchmark of money market returns.

Mirror swap indexes provide total returns of a portfolio of swaps constructed to match the key rate durations of major Lehman bond indexes. For example, the mortgage-mirror swap index uses a portfolio of swaps that matches key rate exposures of the Lehman Mortgage Index and would be used to hedge it. A comparison to the total return of the mortgage-mirror swap index provides an easy way to measure the excess return of the Mortgage Index to a duration-matched portfolio of swaps.

Similar swap indexes will be introduced for the Euro, the British pound, the Japanese yen, and possibly several other currencies at a later time.

Since their arrival in the early 1980s, swaps have grown in importance as a result of several developments in the bond market. Traditionally, investors have accounted for four factors in analyzing fixed-income securities: default-free interest rates, credit spreads, liquidity premiums, and idiosyncratic risk. The U.S. Treasury curve was regarded as a default-free interest rate curve, while a security's spread to a particular Treasury rate was considered to represent its credit risk, liquidity premium, and idiosyncratic behavior. Implicit in this framework is the assumption that Treasuries do not pose any significant liquidity or idiosyncratic risk of their own.

This assumption has come into question in recent years. The Russian default in August 1998 resulted in a spread sector crash and a dramatic increase in the liquidity premium commanded by Treasuries. The U.S. Treasury introduced a further complication in 2000 by beginning to buy back large amounts of its outstanding debt. More recently, the Treasury

suspended issuance of the 30-year bond in November 2001, sparking another strong rally in the 10- and 30-year sectors.

It is now clear that a strong idiosyncratic component in the behavior of long-maturity Treasuries will not go away. In light of these changes in the market, the role of Treasuries as a sole benchmark for fixed-income securities, especially the longer-dated ones, has come under increased scrutiny.

In response to these developments, investors have been searching for an alternative benchmark. A detailed study carried out in late 2000 was devoted to finding an alternative proxy for default-free interest rates from among agencies, swaps, and corporates.[1] The study decomposes yields of fixed-income securities into the risk-free rate and three additional variables representing liquidity, credit, and idiosyncratic risks. A sophisticated econometric technique is employed to extract an unobservable variable representing the risk-free rate. The results of the study confirm that the crisis of 1998 and the Treasury buybacks of 2000 were marked by a dramatic increase in idiosyncratic risk of Treasuries.

More important, the statistical framework developed in the study allows the measurement of common market risk shared by all credit sectors. It is shown that of the instruments considered, swaps represent this common risk best. In other words, of the four components that determine the pricing of fixed-income securities, *swaps represent the default-free interest rate, generic credit, and liquidity common to all investment-grade sectors*. The residual risk specific to a particular sector or security can be characterized in terms of spread to swaps or, equivalently, spread to LIBOR. In light of these findings, the study concludes that swaps work best for hedging products in the spread sector.

It is worth noting that agencies and mortgage-backed securities are already priced relative to swaps and quoted in terms of spreads to LIBOR. As we will show later, the relationships of spreads to Treasuries of swaps, agencies, and MBS have consistently been strong since the crisis of 1998. On the other hand, although swap spreads and corporate spreads are usually highly correlated, this relationship breaks down under stressful market conditions, such as those observed in the aftermath of the September 2001 events. As markets calm down, the correlation between swaps and corporates tends to rise again.

In any case, while swaps are evidently an appropriate proxy for agencies and MBS, many investors are likely to continue using Treasuries as a benchmark for corporate debt. As the U.S. Treasury moves back to deficits for at least three years, the supply of Treasuries should be adequate for hedging purposes in the near term.

I. FIXED-INCOME BENCHMARKS: U.S. TREASURIES AND SWAPS

The main advantage of swaps is that they are not funding instruments, but rather over-the-counter (OTC) contracts used to hedge interest rate risk. For this reason, the supply of swaps is unlimited and is not determined exclusively by issuance. Although hedging of a new bond issue is often the reason to enter into a swap, it is not the only reason. Many swap users are money managers hedging their current bond portfolios and hedge funds taking positions with respect to interest rates. In recent years, the swap market has come to rival Treasuries with respect to size, liquidity, range of maturities, and convenience.

An item-by-item comparison of Treasuries and swaps is given in Exhibit 1.

The Treasury market by contrast is dominated by a single issuer with changing funding needs. There is a similar problem with the agency market, which is effectively driven by only two issuers, Fannie Mae (FNMA) and Freddie Mac (FHLMC). With such a small number of issuers, shocks to supplies in the market can ultimately result in high levels of idiosyncratic risk. The swaps market, on the other hand, is affected by many participants, and thus enjoys a substantial degree of diversification and less idiosyncratic risk. In other words, if a security's spread to Treasuries changes, this may reflect an event specific to the Treasury sector itself rather than the security in question. A change in a security's spread to swaps is much more likely to be caused by developments related to the security or its credit sector.

Recognizing this advantage offered by swaps, investors now widely use them for hedging market risk of spread products. It is a natural next step to compare such securities to swaps with respect to performance as well.

We introduce bellwether swap indexes to track returns of generic fixed-coupon bonds of a given maturity. Mirror swap indexes serve for making duration-adjusted comparisons between swaps and other spread sectors, as represented by their respective Lehman indexes. As mirror swap indexes are simply portfolios of individual swaps, bellwether swap indexes are essential ingredients for constructing the mirror indexes. To the extent that other credit sectors are compared to swaps using a uniform methodology of mirror indexes, swaps can effectively be used for performance comparison.

EXHIBIT 1

Fixed-Income Benchmarks: U.S. Treasuries and Swaps as of September 2001

	U.S. Treasuries	U.S. Interest Rate Swaps
Total Outstanding Notional Value	$2.8 trillion	$15 trillion
Daily Volume	$200 billion	$50 billion
Bid/Ask Spread for $50 Million Trade	¼ basis point running	½ basis point running
Dominant Market Participant	U.S. Treasury	None
Available Maturities	1 month to 30 years	1 month to 30 years
Origination	U.S. Treasury auction	OTC transaction
Supply	Determined by U.S. Treasury issuance	Unlimited
Risk of Short Squeeze	Substantial	None
Counterparty Risk	None	Limited by collateral management, termination provisions, and other credit enhancements

II. WHY USE TOTAL RETURN INDEXES BASED ON SWAPS?

Total return indexes based on swaps will be helpful to investors in many contexts.

Efficient Index Replication

Many portfolio managers are interested in a realistic low-cost strategy for replicating popular Lehman indexes. In general, this is accomplished by assembling a portfolio of relatively few liquid instruments, e.g., Treasury futures, so that the portfolio duration profile matches that of the index to be replicated. As most indexes entail a substantial spread component, the quality of replication can be greatly improved by using swaps, in addition to Treasury futures, to capture the effect of changing credit spreads. Total return indexes for swaps included in the replicating portfolio will be necessary to calculate returns of the replicating portfolio.

EXHIBIT 2

Monthly Tracking Errors of Replicating U.S. Aggregate Index with Swaps and Treasury Futures

Component of the U.S. Aggregate Index	Treasury Futures	Interest Rate Swaps	Swaps and Futures
Treasuries	11.9	55.5	N/A
MBS, Agencies, Credit	46.4	21.3	N/A
Full Index	33.2	26.3	16.0

A typical methodology for constructing a portfolio of derivatives to replicate a bond index works as follows. Initially, all bonds in the index are divided into four cells according to their modified duration, e.g., from 0 years to 3 years, from 3 to 5 years, from 5.0 to 7.5 years, and over 7.5 years. For callable bonds, the modified duration is adjusted using an options pricing model. Each cell is then replicated using one swap or Treasury futures contract of similar duration, e.g., a 2-year swap for the first cell, a 5-year swap for the second, a 10-year swap for the third, and a 30-year swap for the last one. The hedge ratio for each cell is calculated to match the total dollar duration of the cell with that of the respective derivative contract.

Further details are in Dynkin and Lindner [2000].

Exhibit 2 shows average monthly tracking errors of replicating the U.S. Aggregate Index with Treasury futures, swaps, and a combination of the two instruments.[2] Not surprisingly, Treasury futures work well for the Treasury portion of the index, while swaps do better in replicating the spread sector. Most important, a portfolio of swaps and futures used together shows an average tracking error of just 16 basis points per month, which is less than half the error of replicating the index with Treasury futures alone.

Even better results are obtained for the Global Aggregate Index, which enjoys diversification across several currencies.[3] The tracking error of replicating the index with Treasury futures, money market futures, and swaps in four major currencies is as little as 10 basis points per month. It can be further reduced to as little as 4-5 basis points per month if the most liquid bonds from all sectors in the index are used in addition to swaps and futures (see Desclee et al. [2001]).

Security Selection Decisions and Performance Attribution

A security's spread to swaps effectively represents the residual risk of holding that security, after the common risk of spread products is stripped out. For structured securities with embedded options, the spread is calculated using a term structure model for the entire yield curve. The resulting option-adjusted spread (OAS) measures returns from a security's yield, net of the common factor driving the overall market. Money managers use the OAS framework for security selection and relative value analysis.

Option-adjusted spreads have historically been calculated with respect to the Treasury curve. Since 1998, however, investors have increasingly used the OAS to the swap curve, effectively stripping out the liquidity and idiosyncratic components of Treasury yields. The swaps indexes will help facilitate this process by allowing easy computation of returns relative to swaps.

Asset Allocation Decisions

Excess returns to swaps play an important role in asset allocation. To understand the benefits of diversification in a portfolio, investors frequently focus on the correlation of security returns in excess of risk-free interest rates. When this is expressed in terms of excess returns to Treasuries, the correlations are artificially high because of the systematic inclusion of investment-grade credit spreads and the liquidity premium of Treasuries. Using excess returns to swaps, this common factor is further stripped out, leading to improved evaluation of sector allocations.

The correlation matrix of excess returns shown in Exhibits 3A and 3B is based on a ten-year time series of monthly returns from August 1992 through August 2001. In all cases shown, excess returns to swaps exhibit a lower correlation than the corresponding excess returns to Treasuries. In some cases, the difference can be substantial. For example, for agencies versus finance companies, the correlation of excess returns to swaps is only 29% as compared to 55% correlation of excess returns to Treasuries.

For total return investors who are benchmarked to one of the Lehman indexes, the mirror swap index provides an easy mechanism for stripping out the effect of "pure" (i.e., free of liquidity premium and idiosyncratic risk) interest rate movement and isolating the relative performance of a particular credit sector.

EXHIBIT 3A
Correlations of Excess Returns to Treasuries

	Market Sector				
	ABS	Agencies	Finance	MBS	Credit
ABS		58%	74%	44%	67%
Agencies	58%		55%	46%	54%
Finance	74%	55%		45%	94%
MBS	44%	46%	45%		52%
Credit	67%	54%	94%	52%	

EXHIBIT 3B
Correlations of Excess Returns to Swaps

	Market Sector				
	ABS	Agencies	Finance	MBS	Credit
ABS		43%	70%	34%	59%
Agencies	43%		29%	36%	42%
Finance	70%	29%		37%	91%
MBS	34%	36%	37%		46%
Credit	59%	42%	91%	46%	

Benchmark for Money Management

Institutions such as commercial banks, trying to outperform their funding costs that track LIBOR rather than Treasury rates, could use short-maturity (six months to two years) bellwether swap indexes as performance benchmarks. The same is true for money managers with funds invested in commercial paper and other money market instruments.

Pension funds and asset managers looking for very long-duration investments with low risk face a different problem. The reduced issuance and continuing buy-backs of 30-year Treasury bonds make the long end of the Treasury curve inadequate as a benchmark. Long high-grade corporates are not an alternative because of insufficient issuance and idiosyncratic "name" risk. The long agency market also has idiosyncratic risk because of the two major issuers that dominate the sector.

The swap market, on the other hand, with rates and supply determined by many competing market participants, provides the only viable benchmark for this part of the curve. As a result, the long-maturity bellwether swap indexes would be of interest to this group.

New Tools for Risk Management and Excess Returns

The swap indexes also allow us to create new contracts that have several advantages as risk management vehicles. For example, the duration of the Lehman CMBS index is 5.1 years. With prepayment lockouts and constant replenishment with new issues, this number is quite stable. This corresponds to the duration of a six-year swap.

An investor who owns a portfolio of CMBS bonds and pays total returns of the six-year bellwether swap index in an index swap is isolating exposure to the excess returns of CMBS over swaps. This can be further fine-tuned by paying the total returns of the CMBS-mirror swap index.

This strategy can have several advantages over direct use of swaps for hedging. The hedge is automatically rebalanced every month without the need for new transactions. The full value of the hedge is realized every month as a cash flow instead of just a mark-to-market gain. And finally, the transaction is marked to zero each month, thereby reducing counterparty risk without the use of collateral.

III. INTEREST RATE SWAP MECHANICS

A standard interest rate swap works as follows. Two parties, A and B, contract to exchange payments based on an agreed notional amount for a period of time, known as the *maturity* of the swap. The transaction is initiated at zero cost to both parties. Typically, Party A makes quarterly interest payments on the notional amount, based on the three-month LIBOR observed at the beginning of each three-month period. In turn, Party B makes semiannual interest payments on the same notional amount, but at a fixed coupon rate, known as the *swap rate*.

The stream of payments tied to LIBOR is called the *floating leg* of the swap, and fixed coupon payments are called the *fixed leg*. This contract is a *receiver swap* from Party A's perspective and a *payer swap* to Party B.

The London Inter-Bank Offer Rate (LIBOR) that determines the floating-leg payments is an index of published interest rates at which leading banks are willing to lend to each another for a particular period of time. The British Bankers Association (BBA) publishes the end-of-day LIBOR fixings for one-month, three-month, six-month, and twelve-month maturities.[4] The market convention is to quote interest rate swaps with the floating leg rate equal to LIBOR flat. Correspondingly, the swap market for a particular maturity is quoted in terms of the fixed leg swap rate, which is determined by supply and demand.

Interest rate swaps were originally "brokered" transactions in which financial intermediaries with customers interested in a swap would seek counterparties for the transaction among their other customers. If successful, the intermediary collected a brokerage fee, but did not maintain a continuing role once the transaction was completed as the swap counterparties exchanged payments directly. Today, the market has evolved into more of a dealer market dominated by large international commercial and investment banks. Dealers act as market makers; they stand ready to become a counterparty to different swap transactions before a customer for the other side of the transaction is located.

Since swaps are private over-the-counter (OTC) derivative contracts, they are not directly visible to third parties and cannot be traded in the secondary market, unlike bonds and other securities that are designed to change hands freely. In order to get out of a swap, the two parties must negotiate an "unwind," i.e., cancellation of the contract, which typically involves a payment of the marked-to-market value of the contract. Or, rather than cancel a contract altogether, one of the parties can initiate a new swap, possibly with another counterparty, to effectively neutralize the interest rate risk of the original swap.

Exhibit 4 points out some common concerns about swaps. Although swaps are not listed on an exchange like bonds or futures, they are highly standardized and easy to trade. A major effort to ensure smooth trading of swaps has been made by the International Swaps and Derivatives Association (ISDA), a global organization representing leading participants in the derivatives markets. ISDA publishes a standard master agreement to be signed (with minor variations) by any two parties interested in conducting derivatives business with one another. The master agreement specifies how the mark-to-market of transactions shall be calculated, what mutual collateral thresholds apply, the types of derivatives that are netted out for margining, and so on.

At the end of October 2001, the Chicago Board of Trade (CBOT) started trading futures contracts on the ten-year swap. Since the CBOT would act as a counterparty to any investor buying or selling these futures, investors would enjoy the safety of its AAA credit. Trading through the CBOT will also have operational benefits of reduced documentation and central margining and netting. As many institutions are not allowed to deal in

EXHIBIT 4
Possible Concerns Regarding Swaps

Concern:	Swaps are so complex that they can cause settlement disputes between the counterparties.
Response:	The exact procedure for calculating payments and the mark-to-market of all swaps is described in a standardized ISDA master agreement signed by the two parties.
Concern:	Since swaps are made at zero cost, they must increase leverage.
Response:	Like Treasury futures, swaps can actually be used to increase or decrease or to leave leverage unchanged. Their main use is to efficiently adjust the interest rate or spread risk of a portfolio. Swaps are rarely entered into as a stand-alone investment, but usually by hedge funds and other speculative investors with very high risk tolerance.
Concern:	The counterparty may default on a swap.
Response:	Most investors transact with leading trading houses that are highly rated. In addition, the parties usually post collateral to each other, based on the changes in swap value. Further credit enhancements, such as termination upon downgrade or mandatory recouponing, are available to mitigate this risk almost completely.
Concern:	Swaps are not liquid enough.
Response:	The average daily volume of swaps is around $50 billion and growing. The bid/ask spread for a $50 million trade is around ½ basis point, which is better than all other spread products, such as mortgages, agencies, or corporates.
Concern:	Since swaps are not listed on an exchange, the market is not transparent.
Response:	Although swaps OTC products trade mostly through large dealers, swaps rates are easily accessible on Bloomberg, Reuters, broker screens, and dealer websites. Also, ISDA publishes a daily fix for the key swap rates. The introduction of futures settling to swap rates by the Chicago Board of Trade will further increase transparency.

derivatives but are allowed to trade futures, this contract would effectively enable them to participate in the swaps market.

The main risks associated with trading swaps rather than bonds are settlement and counterparty default risk. There are occasional disputes between the parties when a transaction is unwound early. Slight differences in the yield curve interpolation techniques can result in discrepancies in the calculation of the mark-to-market. In practice, allowing swaps to be "assigned" to another party obviates this problem. If Party A wants to unwind a swap but disagrees with Party B about its value, it can effectively sell its interest in the swap to Party C, therefore forcing all parties involved to be competitive in their valuation of the swap.

More significantly, default by one of the parties can cause credit losses for the other party up to several percentage points of the notional value. To control this risk, some swap counterparties require the posting of collateral. For example, if the current value of the swap is in favor of Party A, then Party B is required to post high grade securities of the same value as collateral that can be used by Party A in case of default. The main purpose of the ISDA master agreement is to minimize pricing disputes and ensure that adequate collateral is in place to protect the parties from the credit risk.

IV. SWAPS AS A HEDGING INSTRUMENT

The primary use of swaps is to manage interest rate risk of securities with interest payments tied to LIBOR. For example, a floating-rate borrower paying LIBOR is exposed to rising interest rates. In order to hedge this risk, the borrower can enter into a payer swap, i.e., make fixed-rate coupon payments and receive LIBOR on the notional equal to the amount of debt. Thus, any increase in interest payments that the borrower makes to the lender will be offset by a matching increase in floating payments that the borrower receives on the swap.

The net result is that the borrower effectively makes fixed coupon payments on the amount owed. In other words, the swap enables the borrower to convert floating-rate debt into fixed-rate debt.

Paying fixed (and receiving floating) on an interest rate swap results in an interest rate exposure similar to

issuing a fixed-coupon bond. Receiving a fixed rate on a swap entails the opposite exposure, similar to being long a fixed-coupon bond. A floating-rate note investor can obtain protection from falling rates by entering into a receiver swap. Asset managers who own fixed-coupon bonds and are worried about rising interest rates would enter into a payer swap, thereby converting their bonds from fixed to floating.

The universe of market participants using swaps to hedge interest rate risk is large and diverse. It includes issuers of fixed-income securities, both corporate and financial, seeking to minimize or limit their funding costs. Bond investors, such as insurance companies, mutual funds, and mortgage lenders, use swaps to protect their fixed-coupon investments in a rising interest rate environment. Finally, many hedge funds view swaps as a large liquid market offering opportunities to make money by taking speculative positions and exploiting market volatility.

The presence of many active market participants with opposite interest rates objectives ensures enough liquidity for any one of them to take either side of a swap.

V. SWAPS AS A CREDIT SECTOR

As we noted earlier, LIBOR is an index of interbank lending rates offered by major banks to each other. The average credit rating of these banks tends to be around AA-/Aa2.[5] Hence, LIBOR can be interpreted as a short-term funding rate of a generic highly rated financial company.

The floating leg of an interest rate swap, together with the principal cash flow at maturity, is effectively a floating-rate note (FRN) issued by such an entity. Since swaps are initiated at zero cost, the fixed leg of the swap, together with the principal cash flow at maturity, must be an economically equivalent borrowing arrangement for this company. Thus, the swap rate can be viewed as a fixed coupon that the company would pay on fixed-rate debt of the same maturity as the swap.

The interest rate curve consisting of par swap rates is called the *swap curve*. The swap curve plays an important role in fixed-income markets by virtue of being specifically defined, universally accepted, and highly liquid. Companies that issue fixed-rate debt at yields close to the corresponding swap rates are often referred to as *LIBOR-flat* issuers. Since the U.S. Treasury represents the best credit in the market, swaps trade at a positive spread to Treasuries known as the *swap spread*.

Most swap market participants are investment-grade entities that are closer in credit quality to LIBOR-flat than to U.S. Treasuries. For this reason, the swap curve is a more natural choice for discounting their cash flows than the Treasury curve.

While swap spreads to Treasuries reflect the difference in credit quality between LIBOR-flat issuers and U.S. Treasuries, they bear no connection to the counterparty risk of swaps. The counterparty risk is effectively eliminated through mutual collateral management and other credit enhancements. The sole reason for swap spreads is that floating payments are based on LIBOR, which is an index reflecting short-term funding costs of a generic investment-grade credit.

If the floating side of a standard swap were instead tied to the three-month Treasury yield, the swap rates would not show any spread to Treasuries. Given the actual interest rate swap structure, however, today's swap rate reflects the market's expectation of future values of LIBOR, rather than the three-month Treasury yield, which is a higher number.

Since swap rates can be viewed as equivalent long-term fixed rates available to LIBOR-flat issuers, one may interpret the swap curve as a generic yield curve for highly rated issuers, such as banks that contribute lending rates to LIBOR. In reality, few bonds trade at exactly LIBOR-flat, and when they do it is probably coincidental.

At the end of October 2001, companies with zero option-adjusted spreads to swaps included the Inter-American Development Bank, the province of Alberta in Canada, Austrian Kontrollbank, Florida Power & Light, and Wal-Mart. Most banks whose lending rates are used to calculate LIBOR, however, recorded OAS to swaps in the range of 30 to 70 bp.

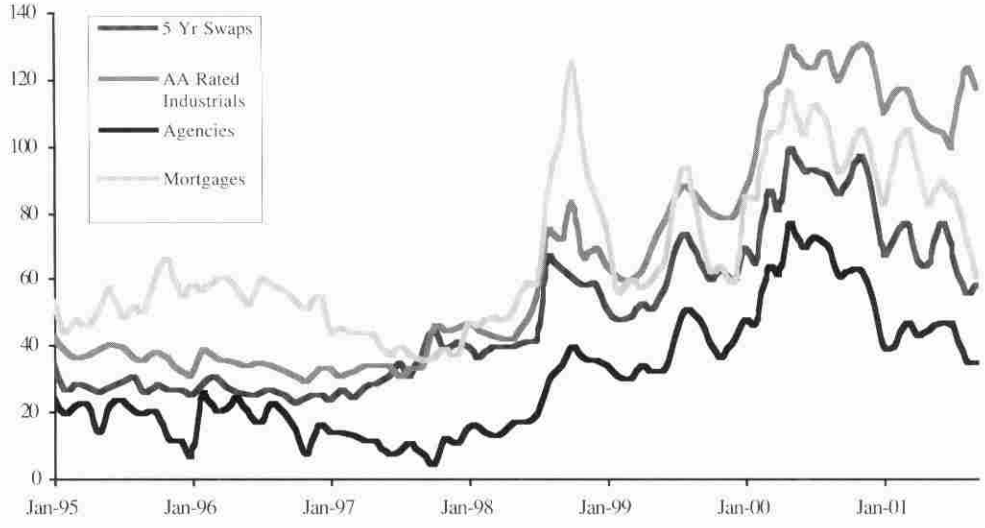
The spread to swaps for such banks is due in part to the idiosyncratic risk of individual names. In addition, if one of these banks is downgraded, it would be replaced by another higher-rated bank for the BBA sampling to set LIBOR. More important, swap rates are determined by supply and demand in the swap market, and are therefore a function of hedging activity.

Many different types of market participants use swaps to hedge interest rate risk. Their motivation is frequently unrelated to debt issuance by highly rated banks. In other words, swaps and high-grade bonds belong to different credit sectors that are linked more symbolically than through a clear market relationship.

This suggests several questions. Is there any connection between swaps and other spread products? If so, how stable is the relationship? To what extent do swaps reflect the behavior of the spread sector as a whole?

EXHIBIT 5

Spreads of Various Credit Sectors to Treasuries (bp)



VI. SWAPS VERSUS OTHER SPREAD PRODUCTS

Initial evidence of a strong relationship between swaps and high-grade securities emerged in the aftermath of the Russian default in 1998. Exhibit 5 shows the history of spreads to Treasuries for five-year swaps, agencies, MBS, and AA-rated industrials. As is evident, all spreads were relatively stable for several years, and then widened together once the crisis broke out. The spread widening was mostly the result of a major flight to quality and an increase in the liquidity premium of Treasuries.

Notably, in spite of high spread volatility, swaps continued to move with other sectors until September 2001. Following the terrorist attacks, agencies and MBS still moved with swaps, while investment-grade corporates decoupled from them.

Specifically, for the period from 1995 through October 2001, the correlation between monthly spread changes of the Lehman Agency Index and the five-year swap is 63%. For the Lehman MBS Index versus five-year swaps the same correlation is 65%. Both numbers are insensitive to the inclusion of September and October of 2001 in the data series. On the other hand, the correlation of spread changes for AA-rated industrials versus seven-year swaps is 53%, but it would be as high as 67% if the two months after the attack were excluded from the data series. These results indicate that swap spreads are a strong explanatory factor for agency and MBS spreads, but the relationship between swaps and corporates is less stable, particularly during crises.

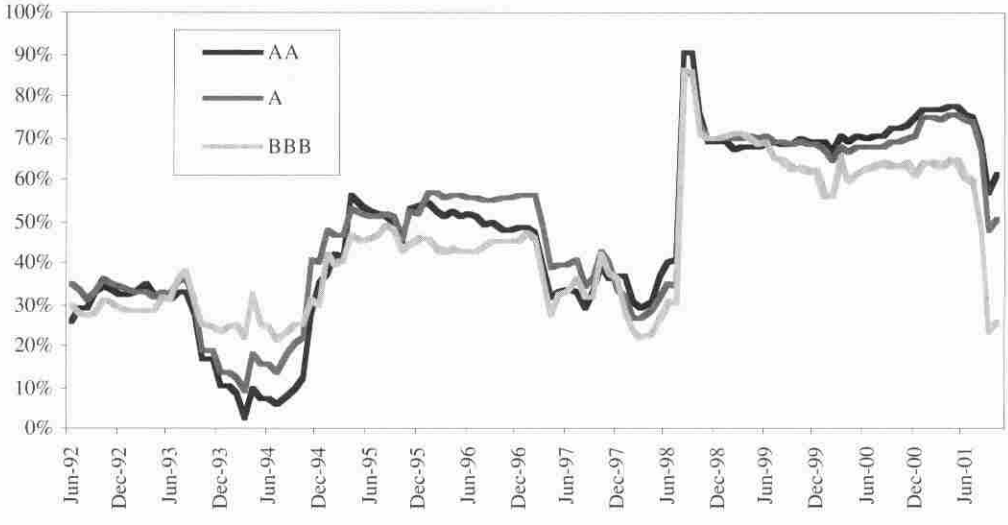
The reason for a strong relationship between swaps and MBS and agency spreads is that the MBS market is dominated by several large buyers of mortgages. These institutions tend to take advantage of any substantial differences between mortgage yields and their own funding costs, as reflected by the agency yields. As a result of their activity in the mortgage market, such discrepancies tend to disappear quickly, forcing the MBS and agency spreads to move together.

On the other hand, the agencies issue both fixed and floating debt, and actively manage their interest rate risk using swaps. If swap rates were to decline, for example, the agencies would seek to reduce their funding costs by issuing more floating debt and swapping it to fixed. Thus, the relative supply of their fixed-rate obligations would decline, causing their spreads to Treasuries to come down in line with the swap spreads. Thus, spreads to Treasuries of the MBS, agencies, and swaps are strongly interrelated and move together.

The relationship of swap spreads and corporate spreads requires further investigation. Exhibit 6 shows the history of the three-year trailing correlation between monthly spread changes of a portfolio of five- and seven-year swaps and five- to ten-year bullet corporates. The correlation rose sharply in the aftermath of the crisis of 1998, going from around 35% to 70%. It remained high for almost three years before collapsing to 45% following the attacks in September 2001.

EXHIBIT 6
Correlation of Spreads to Treasuries for Swaps and Corporates

EXHIBIT 7
Correlation of Swap Spreads and Credit Spreads by Quality



A recent drop in correlation is observed for corporates of all credit qualities, from AA to BBB, as seen in Exhibit 7. The effect is more pronounced for lower-quality bonds, indicating a greater extent of their decoupling from swaps.

Dynkin et al. [November 2001] analyze this market dynamic and propose an explanation. Following the September 2001 attacks, the Fed repeatedly cut interest rates in an attempt to bolster the economy, causing the yield curve to steepen dramatically. Since most corporate issuers carry long-term debt at fixed interest rates, they moved aggressively to convert their debt from fixed to floating and to reduce funding costs by entering into receiver swaps. A significant drop in the overall level of interest rates also caused a wave of mortgage refinancing activity, reducing the duration of mortgage portfolios. In response, MBS investors hedged with receiver swaps to extend the duration of their holdings. These two major

sources of demand for receiver swaps caused swap rates to decline substantially. Over the same period, corporate yields were relatively little changed.

In general, credit quality is the main factor setting lower-rated corporates apart from the agencies, which enjoy the highest credit rating. The funding costs are essentially tied to the level of credit spreads for the former but to the level of interest rates for the latter. The agencies also enjoy easier access to the swap market, where counterparty risk is an issue. As a result, they are in a better position to manage their funding costs using swaps than are most corporates.

The agency spreads are related to the swap spreads more closely than corporate spreads. Thus, market developments of several months following the September 2001 attacks have confirmed that swaps retain their explanatory power for the agencies and MBS spreads, even as they decoupled from corporates.

Although it is hard to predict the future of the relationship between swap spreads and corporate spreads, it seems reasonable to expect that the present steep yield curve will flatten as the economy recovers. The recent widening of the credit-swap spread will likely stop and reverse. Once this occurs, the correlation between corporate spreads and swap spreads will likely revert to approximately 70%.

Stressful market environments strain many market relationships, even those that are normally very close. Once the crises subside, however, the relationships often return to their previous level. This should be the case for credit spreads and swap spreads.

In any case, the events since September 2001 show that the idiosyncratic risk embedded in Treasuries is not going away. Thus, swaps are likely to remain the instrument of choice for hedging market risk.

VII. SWAPS AS A PERFORMANCE BENCHMARK

An investment-grade portfolio hedged with swaps retains exposure to the residual risk of the specific sectors or securities in the portfolio. At the same time, most of the generic risk associated with default-free interest rates and investment-grade credit spreads is stripped out. Therefore, the net effect of hedging a portfolio with swaps is a relative-value position betting that the portfolio would outperform the broad investment-grade universe, as represented by swaps.

Looking at hedging from this perspective suggests another natural application of swaps: as a total return benchmark for investment-grade securities. Total return indexes based on swaps will initially appeal to institutions whose costs of funds closely track LIBOR, such as commercial banks. Money market investors holding very short-duration instruments are also likely to be interested. On the other hand, managers of very long-duration portfolios may also see swaps as a useful performance benchmark, given the shortage of longer-dated Treasuries.

We have argued throughout that swaps are closer by nature to investment-grade securities than are Treasuries. For this reason, swaps are a better hedge for the market risk of such securities, and they also have an advantage as a performance benchmark. For example, during the crisis of 1998 and the buy-backs of 2000, any portfolio with a substantial credit component would have substantially underperformed Treasuries due to spread widening. Yet this relatively poor performance would not have been a fair reflection of a manager's ability to pick the right securities in the investment-grade universe. In order to assess performance of a portfolio properly, one needs to compare it with a well-defined proxy of similar credit quality. Swaps are simply a good proxy for most investment-grade securities.

Since swaps are not funding instruments, we need to define what it means to invest in swaps and measure their performance. So far, we have treated swaps as a proxy for investment-grade securities in the sense that the fixed leg of a swap with the principal paid at maturity behaves as a generic fixed-coupon par bond. How does one effectively invest in such a bond and construct the relevant total return indexes?

VIII. THE LEHMAN SWAP INDEXES

Lehman Brothers is introducing two families of indexes to track the performance of swaps. We view each swap of a given maturity as a fixed-coupon par bond of the same maturity, and we construct a total return index for the swap. This is done for all swaps with maturities that are considered bellwethers, giving rise to *bellwether swap indexes*. These indexes provide answers to questions like: What are historical total returns for ten-year swaps?

In addition to individual bellwether indexes, we introduce the *flagship swap index* to represent the performance of swaps collectively as a market sector. The Lehman Swap Index tracks total returns of an equally weighted portfolio of 30 swaps with maturities of 1 year, 2 years, and annual increments thereafter out to 30 years.

An important benefit of bellwether swap indexes is the ability to measure performance of other credit sectors

with respect to swaps. Lehman already publishes a number of established total return indexes for various market sectors. For a particular index, such as the Lehman Agency Index, the corresponding *mirror swap index* tracks a portfolio of six specific bellwether swaps. The notional amounts of these swaps are chosen to match the key rate durations of the original index.

In other words, the mirror index is a portfolio of swaps that would be used to hedge the market risk of the original index. The excess return of the Lehman index relative to swaps can then be calculated as the difference between the original index and its mirror swap index.

Bellwether Swap Indexes

In the U.S. market, interest rate swaps with certain maturities, such as 2, 3, 5, 10, 20, and 30 years, are considered bellwethers, with easily observable markets and liquid trading. For each of these swaps, we produce a time series of monthly total returns that would result from investing in a hypothetical generic bond with a coupon equal to the fixed rate of the swap and paying the principal at maturity.

Note that the only features that distinguish a receiver swap and a corresponding fixed-coupon bond are as follows:

- The swap is effectively a long position in a fixed-coupon bond, plus a short in the floating leg (with principal).
- At inception and on all quarterly payment dates, the floating leg is worth exactly par because it represents borrowing at the prevailing market rate.
- The swap is initiated at zero cost, while the bond must be worth par because the value of the fixed leg initially equals that of the floating leg.

As swap is economically equivalent to buying a generic fixed-coupon bond and funding it at LIBOR on a rolling basis. An investor wishing to buy the bond outright with available cash does not need the funding. To obtain an equivalent position using swaps, the investor could enter into a swap and use cash to fully offset the funding aspect of the swap by investing it at three-month LIBOR. Over the first three months of the swap, this strategy can be summarized by the equation:

$$\begin{matrix}\text{Fixed-Coupon} \\ \text{Par Bond}\end{matrix} = \begin{matrix}\text{Par Swap + 3-Month LIBOR} \\ \text{Cash Investment}\end{matrix}$$

At the end of the first quarterly period, the floating leg of the swap would again be worth par and pay interest at the rate of LIBOR observed at the inception of the swap. That is exactly the case with our proposed cash investment at three-month LIBOR as well. Thus, the cash investment offsets the floating leg of the swap perfectly over the first three months and every three-month period thereafter.

In light of this analysis, we define the total return of a swap to be the return on a portfolio consisting of the swap and the cash investment at LIBOR. The total return of this portfolio is exactly the same as the total return of the fixed leg of the swap treated as a bond.

Note that LIBOR as published by the British Bankers Association represents the average *offer* rate at which leading banks are willing to *lend* to each other. The average rate at which the same banks are willing to borrow money, i.e., the bid side of the lending market, is lower, and is known as the London Interbank Bid Rate (LIBID). Typically, a bank's bid rate is around 12 basis points lower than its corresponding offered rate. To account for this factor, Lehman will be subtracting 1 bp per month or, equivalently, 12 bp per year from the total return of all swap indexes.

The rules for calculating total returns on the bellwether swap indexes are:

- ***Securities.*** Lehman will publish the total returns of swaps of 3-month, 6-month, 1-year, and annual maturity increments thereafter out to 30 years, for a total of 32 swaps.
- ***Rebalancing.*** In accordance with our current policy of keeping the total return universe fixed during each calendar month, we assume that the proposed portfolio consisting of a par swap and a cash investment is created on the last business day of each month. The portfolio is liquidated on the last business day of the following month, and is replaced by a new trade of a par swap and a cash investment. On the unwind date (which defines the total return for the swap for that month), the swap is one month shorter than at inception.
- ***Coupon.*** New swaps are initiated on the last calendar day of the month at par. The coupon on the swap is the par coupon as obtained from the closing mid-market marks for swap rates from the most recent business day. A consequence of this rebalancing approach is that the coupon, duration, and convexity of the swap would experience a small jump every month.

- ***Mark-to-Market.*** The total returns calculated on any day will be based on the closing mid-market swap curve for that day.
- ***Settlement.*** For the purpose of calculating total returns, we assume settlement on swaps is in one calendar day. This contrasts with standard settlement in the U.S., which is in two business days. We use this convention to conform to other Lehman indexes, allowing direct comparison of swap total returns with the other indexes.

Swap Index

We view swaps as a benchmark for the broad high-grade bond market. To represent this market with a single variable, we introduce the swap index tracking a portfolio of swaps with a wide range of maturities. Specifically, the portfolio is assumed to include *equal notional values* of each of the bellwether swaps with maturities of 1 year, 2 years, and so forth up to 30 years in annual increments.

As with individual bellwether swaps, we rebalance the portfolio the end of each month. At that time, all swaps in the portfolio are unwound, and a new portfolio of 30 current par swaps is composed and tracked over the next month.

Annual total returns for selected bellwether swaps, the main swap total return index, and a number of popular Lehman sector indexes are shown in Exhibit 8A.

Mirror Swap Indexes

The purpose of mirror indexes is to track the performance of high-grade indexes relative to swaps. We construct a separate mirror swap index for each of the established Lehman indexes: Aggregate; Government/Credit; Credit; Agencies; and MBS.

Each mirror index will reflect the performance of a weighted *portfolio* of bellwether swaps with the maturities of 6 months and 2, 5, 10, 20, and 30 years. The mechanics of investing in a particular swap in the portfolio are identical to those described for bellwether swaps. The appropriate notional amount of each swap will be chosen to produce the same key rate exposure profile for the mirror index portfolio as for the particular Lehman index with which it is compared.

Exhibit 8B shows monthly excess returns of major Lehman indexes over swaps for 2001. Excess returns are calculated as the difference between an index and its respective mirror swap index.

EXHIBIT 8A

Total Returns of Bellwether Swaps, the Swap Total Return Index, and Major Lehman Sector Indexes (%)

	Bellwether Swaps								
	2 yr	5 yr	10 yr	30 yr	Swap Total Return Index	U.S. Treasuries	Agencies	MBS Fixed-Rate	U.S. Credits
1993	6.1	10.9	14.7	18.1	15.0	10.7	10.5	6.8	12.2
1994	0.0	−4.2	−7.0	−8.3	−6.9	−3.4	−3.3	−1.6	−3.9
1995	12.4	18.8	25.8	37.9	28.4	18.4	18.3	16.8	22.2
1996	5.2	3.3	1.1	-1.7	0.6	2.7	3.3	5.4	3.3
1997	6.7	8.4	11.3	16.7	12.8	9.6	9.7	9.5	10.2
1998	7.4	9.7	12.3	14.5	12.3	10.0	8.8	7.0	8.6
1999	3.2	−1.1	−6.2	−12.8	−7.6	−2.6	−0.9	1.9	−2.0
2000	9.1	12.1	16.0	21.7	17.3	13.5	12.2	11.2	9.4
2001	10.0	10.2	9.0	8.0	8.6	6.7	8.3	8.2	10.4
Mean	6.7	7.6	8.6	10.5	9.0	7.3	7.4	7.2	7.8
Std Dev	3.7	7.1	10.8	16.0	11.7	7.2	6.7	5.3	7.9
Duration as of Dec 2001	1.9	4.4	7.7	13.6	9.2	5.9	4.3	3.1	5.5

EXHIBIT 8B

Excess Returns of Major Lehman Indexes Over Swaps for 2001 (%)

	Lehman Index				
	Aggregate	Gov Credit	Credit	Agency	MBS
January	–0.17	–0.16	0.82	–0.22	–0.19
February	–0.24	–0.21	–0.39	–0.14	–0.32
March	0.03	0.13	0.24	–0.01	–0.12
April	0.00	–0.05	0.34	–0.07	0.06
May	0.09	0.09	0.45	–0.13	0.10
June	0.24	0.37	0.43	0.14	0.01
July	–0.38	–0.41	–0.35	–0.34	–0.36
August	–0.16	–0.20	–0.17	–0.21	–0.11
September	–1.40	–1.85	–3.06	–0.44	–0.67
October	0.11	0.17	0.15	0.25	0.04
November	0.17	0.63	1.43	–0.05	–0.64
December	0.15	0.24	0.41	0.08	–0.03

EXHIBIT 9

Construction of Agency-Mirror Swap Index for November 2001

Par Maturity	Agency Index Key Rate Durations	Swap Duration	Hedge Ratio	Swap Notional	Swap Total Return (%)
6 Months	0.13	0.49	27.38%	221,351,531	0.2184
2 Years	0.72	1.94	37.18%	300,575,619	–0.4757
5 Years	1.12	4.54	24.79%	200,344,688	–1.9893
10 Years	1.15	8.05	14.33%	115,861,235	–3.6965
20 Years	0.74	12.47	5.97%	48,232,292	–5.4380
30 Years	0.61	14.69	4.15%	33,568,472	–5.8717
Cash			–13.81%	(111,605,477)	0.1739

Index Return: *–1.79%*
Mirror Return: *–1.73%*
Lehman Agency Index market value: 808,328,359

Exhibit 9 gives an example of construction of the agency-mirror swap index at the end of October 2001. The six key rate durations of the Lehman Agency Index are computed for each maturity. The key rate duration of a security is defined as the sensitivity of the value of the security to a change in the key maturity swap rate, divided by the value of the security.[6] The key rate duration of a portfolio, such as the Lehman Agency Index, is the weighted average of key rate durations of individual securities in the index weighted by their respective market values.

We next determine the hedge ratios for the six swaps in the mirror portfolio by dividing the key rate durations by their respective swap durations. In order to ensure that the agency index and its mirror swap index have exactly the same sensitivity to a change in the key swap rate, the notional amount of each swap is taken to be the product of the agency index market value by the respective swap hedge ratio.

Since the total investment in the mirror swap index must equal the market value of the agency index, any residual capital left over from swaps is invested in cash. In other words, the hedge ratios for the six swaps and cash add up to one. The amount invested in cash may be negative, as is the case in our example.

EXHIBIT 10
Standard Deviations of Excess Returns to Treasuries and Swaps

Index	Period*	Std. Deviation of Monthly Excess Returns to Treasuries (bp)	Swaps (bp)
Aggregate	Pre-Crisis	13	13
	Post-Crisis	25	15
Agencies	Pre-Crisis	10	15
	Post-Crisis	29	17
MBS	Pre-Crisis	36	35
	Post-Crisis	34	22
Credit	Pre-Crisis	22	24
	Post-Crisis	57	45

**The pre-crisis period covers 1992 through July 1998. The post-crisis period is January 1999 through August 2001.*

Like other Lehman indexes, mirror swap indexes are rebalanced on the last business day of each month. At that time, all swaps in the mirror portfolio are unwound, and the total return is calculated as the notional weighted average of returns for six bellwether swaps. Next, the key rate exposures of the Lehman index are recalculated, and a new mirror portfolio is assembled. Monthly rebalancing ensures that swaps in the mirror index are close to par and thus reflect the actively traded portion of the market.

Since interest rate risk profiles of the Lehman index and its mirror swap index are similar, it is reasonable to define the excess return to swaps as the difference between the original index and its mirror swap index. In the example shown in Exhibit 9, swaps outperformed agencies by 6 bp in the month of November 2001.

For a particular Lehman index, excess returns to Treasuries or swaps can also be interpreted as a tracking error of replicating the index with these respective instruments. The smaller the tracking error, the lower the basis risk of hedging the index using Treasuries or swaps.

Exhibit 10 shows the average tracking errors, calculated as a standard deviation of monthly excess returns, which result from replicating several popular Lehman indexes. The mirror portfolios of Treasuries and swaps used in this analysis are composed to match the overall duration of the index in question, rather than its key rate durations. This enables us to produce a time series of excess returns going back to 1992.

As is evident in Exhibit 10, Treasuries tracked spread products better than swaps prior to the crisis of 1998. This reflects the relative stability of spreads to Treasuries, which allowed investors to hedge their interest rate risk with Treasuries and led markets to quote prices in terms of spreads to Treasuries. In the aftermath of the crisis, spread products decoupled from Treasuries and then were tracked better by swaps until September 2001. Investors largely switched from Treasuries to swaps as a hedging instrument of choice, and prices were increasingly quoted in terms of spreads to swaps.

One should note, however, that although swaps exhibit less tracking error than Treasuries, the post-crisis numbers are substantially higher than the pre-crisis numbers for both Treasuries and swaps.

IX. REPLICATION OF SWAP INDEXES

Once investors actively start using swap indexes as a performance benchmark, they will need an easy and cost-efficient way of replicating their returns by trading real securities and derivative contracts. Our proposed strategy of investing the principal at three-month LIBOR and entering into a receiver swap gives rise to several technical issues.

What are the transaction costs of doing swaps? The bid-ask spread on a standard interest rate swap is about one-half basis point running (i.e., per year for the life of the swap). For a ten-year swap with a duration of approximately seven years, this cost would amount to eight years $\times$ ½ bp/yr. = 4 basis points up-front to put the trade on and unwind it later. If swaps are initiated and unwound monthly as the index prescribes, the total cost of replicating the ten-year bellwether swap would be around 12 months $\times$ 4 bp/month = 48 bp per year, which is obviously extremely high.

The cost of replicating the main swap index with average duration of 9 ½ years would be even higher, at 57 bp per year.

What are the alternatives to earning the LIBID? An investor seeking to earn the three-month LIBOR, rather than the lower LIBID, could turn to the short-maturity asset-backed commercial paper (ABCP) market. The size of the market for high-rated ABCP in late 2001 was around $675 billion, and the yields range from around LIBOR −8 bp for the most liquid issues up to LIBOR + 8 bp for the less liquid ones. The exact levels depend on the program, size, seasoning, and other factors.

Any commercial paper, however, is subject to the idiosyncratic risk of a particular issuer, and hence possible spread widening and liquidity constraints. Investors who

can take slightly more spread risk can get somewhat better returns on one- to two-year AAA asset-backed floaters.

Are there cost-effective ways to closely replicate a swap index? It is possible to reduce transaction costs substantially by rebalancing a portfolio quarterly rather than monthly. In doing so, one would never have to unwind the cash investment, and the transaction costs on swaps would be reduced substantially. Each monthly roll amounts to replacing a swap with a very similar swap of a slightly longer maturity. In addition, if an investor enters into a quarterly program roll with a dealer, the resulting transaction discount would reduce costs to as little as 5 bp a year.

Another possibility is to use swaps with payment dates on the floating side matching the International Monetary Market (IMM) dates of the Eurodollar futures. Such swaps have very similar risk characteristics to standard swaps, yet they can be hedged cheaply using the Eurodollar futures, at a cost of half a basis point per contract. Since contracts would expire and be replaced only once a quarter, the total cost of hedging such swaps is only about 2 bp per year.

Whatever replication strategy one chooses to use, it would introduce a small tracking error. For example, if the portfolio mimicking the ten-year bellwether swap is rebalanced quarterly rather than monthly, the resulting tracking error comes out to around 3 bp per month. Similar results can be expected in the case of replication with Eurodollar futures.

X. CONCLUSION

The swap indexes are an important addition to the Lehman family of global fixed-income indexes. Their main purpose is to track performance of a key fixed-income market segment. Investors will also find the swap indexes helpful in replicating the established Lehman sector indexes using swaps, as well as in asset allocation decisions and relative value analysis. The swap indexes will provide an important new standard for fixed-income markets, enabling investors to look at various securities and credit sectors from a new perspective.

Over time, as swaps continue to grow in popularity with the investor community, the swap indexes may be used as a performance benchmark for money managers focused on investment-grade securities. A number of low-cost strategies are available to investors seeking to replicate the swap indexes with a small tracking error. They can expect transaction costs to be as low as 5 basis points annually.

ENDNOTES

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[1]See Kocic, Quintos, and Yared [2000].

[2]Tracking error is defined as the standard deviation of the difference between monthly returns of the index and the replicating portfolio.

[3]See Dynkin et al. [March 2001].

[4]For the U.S. dollar, these can be found on Telerate, p. 3750.

[5]The official list of contributing banks for major currencies is available on the British Bankers Association website at http://www.bba.org.uk/media.

[6]Historically, key rate durations of Lehman indexes have been calculated with respect to the U.S. Treasury curve rather than the swap curve. To maintain consistency, we calculate sensitivities of the mirror portfolio to changes in Treasury yields subject to constant swap spreads. Since our analysis calls for using the swap curve rather than the Treasury curve, all key rate durations should be based on perturbations of swap rates. This would also make calculations used for construction of the mirror index portfolio straightforward. Although we intend to use the swap curve in the long term, the numerical difference between these two approaches is insignificant.

REFERENCES

Desclee, A., L. Dynkin, and V. Konstantinovsky. "Replication of the Lehman Global Aggregate Index with Cash Instruments." Lehman Brothers, Global Relative Value, August 2001.

Dynkin, L., J. Hyman, P. Lindner, and J. Mann. "Replication with Derivatives: The Global Aggregate Index and the Japanese Aggregate Index." Lehman Brothers, March 2001.

Dynkin, L., A. Kocic, P. Lindner, and B. Phelps. "Weaker Swap-Credit Market Correlation: Temporary or Permanent?" Lehman Brothers, Global Relative Value, November 12, 2001.

Dynkin, L., and P. Lindner. "Replication of Index Returns with Treasury Futures, Eurodollar (Euribor) Futures, and Swaps." Lehman Brothers, March 2000.

Kocic, A., C. Quintos, and F. Yared. "Identifying the Benchmark Security in a Multifactor Spread Environment." Lehman Brothers, September 2000.