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RESEARCH AND PRODUCT DEVELOPMENT

Curve Trades with Eurodollar and Interest Rate Swap Futures Spreads

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This paper provides a brief overview of the Interest Rate Swap – Eurodollar futures spread: why it is attractive, how to set it up and what makes it work.

Spreads between Eurodollar (ED) futures and Interest Rate Swap futures furnish simple and direct means to take views on the shape of the swap rate curve. Importantly, each leg of the Swap-ED spread is ultimately anchored to LIBOR:

- Swap futures reference fixed rates on intermediate- and long-term USD plain-vanilla interest rate swaps. (For more information on Swap Futures, see the *Interest Rate Swap Futures Reference Guide*, available from the Interest Rate Resource Center at www.cmegroup.com/ircenter.)
- USD plain-vanilla swap rates, in turn, reflect market participants' expectations of the future course of USD 3-month LIBOR, the underlying reference for ED futures.

This tight fundamental link makes the Swap-ED spread comparatively robust to the sorts of systemic dislocations that have disrupted the performance of many other inter-market relative value spread positions in recent years.

Profitably managing the spread position means keeping an eye on the spread ratio at the heart of the trade. Section 1, and in greater detail the Appendix, spells out the spread ratio's key components:

- *The Swap futures DV01* is detailed in Section 2. This is simply the price sensitivity of the Swap futures contract, as gauged by the dollar value of a 1 basis point (bp) move in the contract's underlying reference swap rate.
- *The ED contract rate beta* is taken up in Sections 3 and 4. This indexes the volatility of the forward-starting 3-month LIBOR referenced by the ED leg of the spread, relative to the volatility of the Swap futures' underlying reference swap rate.

Among many attractive features of the Swap-ED spread is its capital efficiency, insofar as the legs tend to be eligible for significant performance bond reductions. This is discussed in Section 5.

The spread between the ED futures Blue Pack and 10-Year Swap futures makes several illustrative appearances. Section 6 examines its historical performance characteristics.

(1) Swap-ED Spread Mechanics

If chosen properly, the spread ratio insulates the trade's profit and loss (P/L) from uniform changes in the general level of interest rates. This ensures that the position generates P/L only if the two contract rates – the forward-starting swap rate that underlies Swap futures, and the forward-starting 3-month LIBOR that underlies ED futures – move by different amounts. We achieve this by setting the spread ratio as:

$$Spread\ Ratio = DV01_{Swap} \,/\, (DV01_{ED} * ß)$$

This is simply the ratio of the Swap futures price change to the ED futures price change, in each case in response to a 1 bp move in the Swap futures contract rate ($DV01_{Swap}$ for the Swap futures contract, and $DV01_{ED} * ß$ for the Eurodollar futures). Arbitrarily, we apply the spread ratio to the ED leg of the trade, expressing it as the number of ED futures contracts per Swap futures contract.

Market convention is to reference ED futures expirations in terms of a color code, with 4 contract expirations per color. On any given date the nearest 4 quarterly expirations (the nearby and the next 3 thereafter) are termed the White year, or the Whites. The next 4 quarterly expirations beyond the Whites are the Reds. The next 4 quarterly expirations beyond the Reds are the Greens, and so on. Eurodollar packs are designated similarly. The following table summarizes:

ED Futures Expiration Year	ED Pack
1	White
2	Red
3	Green
4	Blue
5	Gold
6	Purple
7	Orange
8	Pink
9	Silver
10	Copper

$DV01_{ED}$, the dollar value of a 1 bp interest rate change for an ED futures contract, is always a fixed amount, dependent only upon the ED futures structure that we decide to use. If we build the ED leg of the spread with a single contract expiry (e.g., the first Red ED contract), then $DV01_{ED}$ is always \$25. If instead we use an ED Pack (e.g., the Blue Pack), then $DV01_{ED}$ is always \$100. (For more on this, see Section 3.)

The ß in the expression's denominator is the ED rate beta that allows for the possibility that the ED contract rate may be systematically more or less volatile than the Swap futures contract rate. If ß were equal to one, then on average, the two rates would move in lockstep, bp for bp. A ß value greater than one would signify that the ED contract rate is systematically more volatile than the Swap futures contract rate. See the Appendix for more details.

The next three sections, in turn, discuss each of these aspects of the Swap-ED spread – the Swap futures DV01, the choice of ED futures contract or contract combination and the ED contract rate beta.

(2) The Swap Futures DV01

Interest Rate Swap futures listings currently include 5-year, 7-year, 10-year and 30-year maturities. In essence, each Swap futures contract references a plain-vanilla forward-starting par swap rate. The contract's pricing mechanism transforms the par swap rate into an index number that looks and behaves like the price of a 6 percent coupon note.

Importantly for spread traders, the mapping from the par swap rate to the Swap futures price is standardized and one-to-one. Each Swap futures price level corresponds to a single swap rate and a single DV01 value, regardless of either the contract's time to expiry or market conditions.

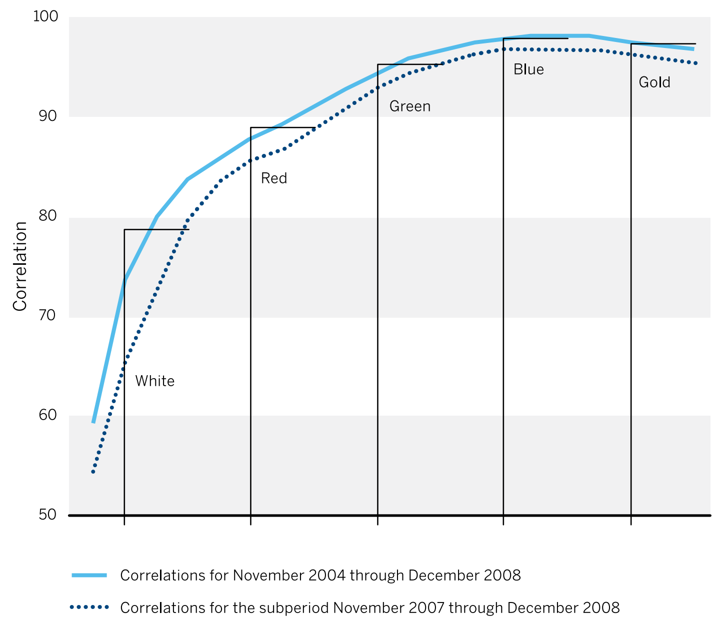
The implied swap rates and DV01s for each Swap futures contract, at each contract price level, are published by the Exchange and are freely available. (See *Swap Futures Price-Yield Tables*, available at the Interest Rate Resource Center at www.cmegroup.com/ircenter.) In addition, the Interest Rate Swap Futures Fact Card, also available at the Resource Center, summarizes contract terms and conditions.

(3) Structuring the ED Leg

We might set up a Swap-ED spread position on the basis of our expectations regarding particular points along the forward LIBOR curve. For example, if we are reasonably confident that forward 3-month LIBOR rates in the Red expiry year are poised to rise relative to 10-year plain-vanilla swap rates, then we might buy 10-Year Swap futures and sell a suitable number of, say, the first Red ED futures or the Red ED Pack.

If instead we aim to set up the spread with its risk management attributes in mind, then we might prefer to choose a Eurodollar structure on the basis of the correlation of its price dynamics with Swap futures. As Exhibit 1 suggests, for 10-Year Swap futures the tightest correlations occur among ED contracts expiring in the Green year and beyond, with pride of place going to Blue year expiries. On this evidence, we might opt for the ED Blue Pack as the ED leg of the spread.

Exhibit 1:
How 10-Year Swap Futures Correlate with the ED Futures Strip: White, Red, Green, Blue, and Gold Expiries, Nov 2004 to Dec 2008

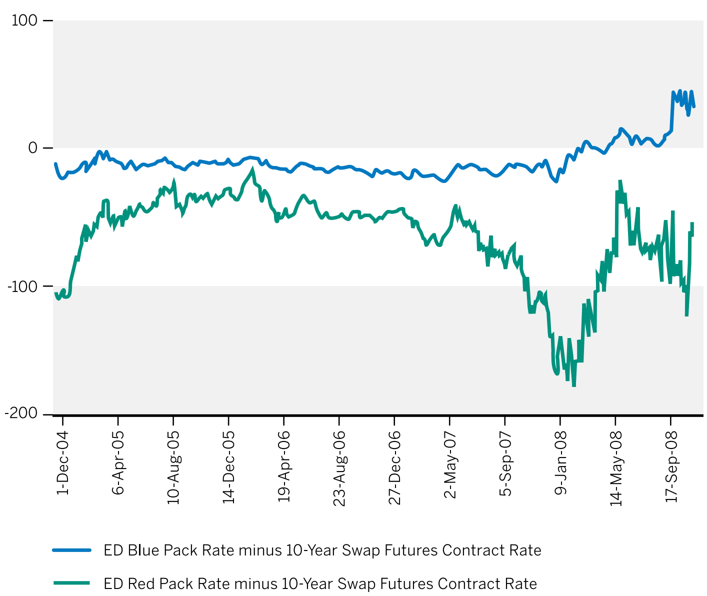


Notes: Shown are Spearman rank correlations of daily close-to-close changes in nearby 10-Year Swap futures prices with daily price changes in the 20 nearby ED futures contracts and the five nearby ED packs. The convention for identifying members of the ED futures strip and nearby Swap futures on any given date is to assume, arbitrarily, that market participants roll from the current quarterly expiry cycle into the deferred cycle on the last business day of the month before the current cycle's expiration. For example, on the last business day of August 2008, one would shift the first Red contract from the Sep08 expiry to the Dec08 expiry, and so on for all other delivery months.
Data source: CME Group

Sidenote: Exhibit 1 reveals surprising robustness in the correlative relationship between Swap futures and the ED futures strip. The ruction in interbank money markets and interest rate swap markets during 2008 produced little change in the correlation profile between 10-Year Swap futures price dynamics and ED futures price dynamics. Unsurprisingly, correlations dropped. Remarkably, the drop in correlation magnitudes was both modest and reasonably uniform.

To make the consequences of this decision concrete, Exhibit 2 shows historical spreads, measured in bps, between nearby 10-Year Swap futures contract rates and ED Red Pack and Blue Pack rates. The ED Red Pack version of the spread clearly presents a more adventuresome risk profile than the ED Blue Pack version, even in relatively placid market conditions.

Exhibit 2:
Swap-ED Spreads: ED Red Pack and ED Blue Pack Rates minus 10-Year Swap Futures Contract Rates
(Daily Closes, Dec 2004 – Nov 2008 Basis Points)



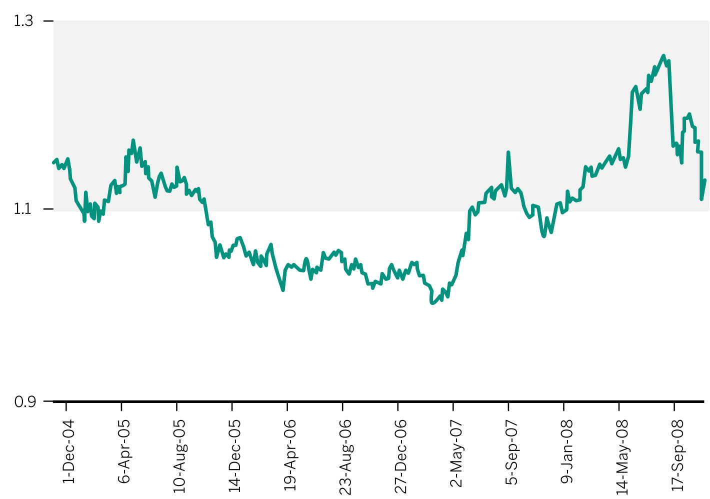
(4) ED Rate Betas

If ED futures contract rates moved in lockstep with Swap futures contract rates, then we would know all we need to know to determine our spread ratio. In practice, however, contract rate dynamics differ systematically between the two. In recent years, for example, the ED Blue Pack rate has tended to move 1.12 bps on average for every 1 bp change in the 10-Year Swap futures contract rate.

If we were to neglect this in setting the spread ratio, then the resultant spread position would be effectively tilted toward overexposure to the ED futures leg by around 12 percent.

The rate beta bears periodic monitoring, as its value may vary from time to time. Exhibit 3 indicates, for example, that the ED Blue Pack's rate beta versus the 10-Year Swap futures contract rate has vacillated widely in recent years, from 1.00 or so during first quarter of 2007 to values exceeding 1.25 during Summer 2008.

Exhibit 3:
ED Blue Pack Rate Betas versus 10-Year Swap Futures Contract Rates
(Change in ED Blue Pack rate per 1-bp change in 10-Year Swap futures contract rate, Dec 2004-Nov 2008, Basis Points)



Notes: Shown are coefficient estimates for rolling quarterly (63-business-day) regressions of daily changes in ED Blue Pack rates upon daily changes in contract rates implied by nearby 10-Year Swap futures prices. The convention for identifying members of the ED futures Blue Pack and the nearby Swap futures contract on any given date is to assume that market participants roll from the current quarterly expiry cycle into the deferred cycle on the last business day of the month before the current cycle's expiration. For example, on the last business day of August 2008, one would shift the first Blue contract from the Sep11 expiry to the Dec11 expiry, and so on for all other delivery months.
Data source: CME Group

(5) Swap-ED Spread Ratios and Margin Efficiencies

Suppose that on Tuesday afternoon, January 6, 2009, we decide to spread 10-Year Swap futures against the ED Blue Pack. To set the spread ratio, we gather its elements:

- The daily settlement price for March 2009 10-Year Swap futures is 127 and 16.5/32nds. A quick visit to the Swap Futures Price-Yield Tables informs us that the implied forward-starting 10-year swap rate associated with this price level is 2.823 percent and that the contract DV01 at this price level is $100.21 (i.e., 3.2/32nds).
- The DV01 for the ED Blue pack is of course $100, equal to 4 contracts x $25 per bp per contract.
- Assume that the appropriate rate beta for the ED Blue Pack is its long-term average value of 1.12

We find the spread ratio to be:

$$DV01_{Swap} / (DV01_{ED} * ß)$$
$$= \$100.21/(\$100 * 1.12)$$
$$= 0.895 \text{ ED Blue Packs per Swap Futures}$$

If we expect the ED Blue Pack rate to rise relative to the 10-Year Swap futures rate, then for every 1,000 10-Year Swap futures we buy, we would sell 895 ED Blue Packs (i.e., 3,580 ED futures, equal to 4 x 895 ED Blue Packs).

Given the scale of this position, the margin impacts are surprisingly modest. On January 6, 2009, the minimum initial performance bond postings that CME Clearing requires for a hedger carrying commercial exposure to plain vanilla swap rates and/or interbank interest rates is $2,800 per contract for 10-Year Swap futures, and $1,100 per contract for Tier-2 Eurodollar futures (i.e., any ED futures contract expiring in the Blue year or beyond).

Importantly, the performance bond offset that CME Clearing would recognize for spreads between 10-Year Swap futures and Blue year ED futures is:

> 70 percent for long/short seven ED futures versus short/long two 10-Year Swap futures.

Thus, the initial margin posting for a hypothetical Swap-ED spread position comprising 1,000 10-Year Swap futures and 3,580 ED futures would be $2,083,000, a bit less than 2.1 percent of the position's notional underlying amount of $100 million. Here's the reckoning:

1,000 Swap futures @ $2,800	=	$ 2.80 mln
+ 3,500 ED futures @ $1,100	=	$ 3.85 mln
= Subtotal	=	$ 6.65 mln
30% of Subtotal	=	$ 1.995 mln
+ 80 ED futures @ $1,100	=	$ 0.088 mln
= Grand Total	=	$ 2.083 mln

Two points are worth noting. First, as a prudential matter, minimum contract performance bonds and spread-related reductions in those minimum performance bonds are reviewed regularly by a committee of Exchange and CME Clearing officials, and are changed periodically in response to fluctuations in either market volatility, or the degree of correlation among different segments of the yield curve, or both. For current performance bond requirements, please visit www.cmegroup.com/margins. Second, this discussion of performance bond reduction makes reference only to the minimum performance bond set by CME Clearing for its clearing member firms. Individual clearing member firms may, and often do, require their customers to maintain higher minimum levels of performance bond against the positions they hold in their accounts.

(6) Trade Performance

Returning to Tuesday afternoon, January 6, 2009, we buy the Swap-ED spread on the following terms:

- Buy 1000 Mar09 10-Year Swap futures @ 127 and 16.5/32nds
- Sell 895 ED futures Blue packs, i.e., 895 of each of the following ED contracts:

  Mar12 @ 97.22
  Jun12 @ 97.16
  Sep12 @ 97.11
  Dec12 @ 97.03

Suppose we hold this spread for a week. Happily, as we had anticipated, the ED Blue Pack rate has risen relative to the Swap futures contract rate – in this event, by around 2.3 bps. By January 13, the Swap futures contract rate has fallen 34.2 bps, making a rise in contract price of 111.5/32nds. At the same time, the average contract rate across the ED Blue Pack has declined nearly 31.9 bps. As Exhibit 4 summarizes, the position generates a profit of just over $631,560.

Exhibit 5 generalizes upon this example. It indicates for various spans of recent history the distribution of P/L for Swap-ED spread trades with one-week holding periods (typically Wednesday to Wednesday, with the following Thursday standing in whenever Wednesday is a holiday).

As the fitted quadratic regression functions in Exhibit 5 suggest, one of the fundamental themes in the Swap-ED spread is the difference in how Swap futures and ED futures prices respond to the same interest rate change:

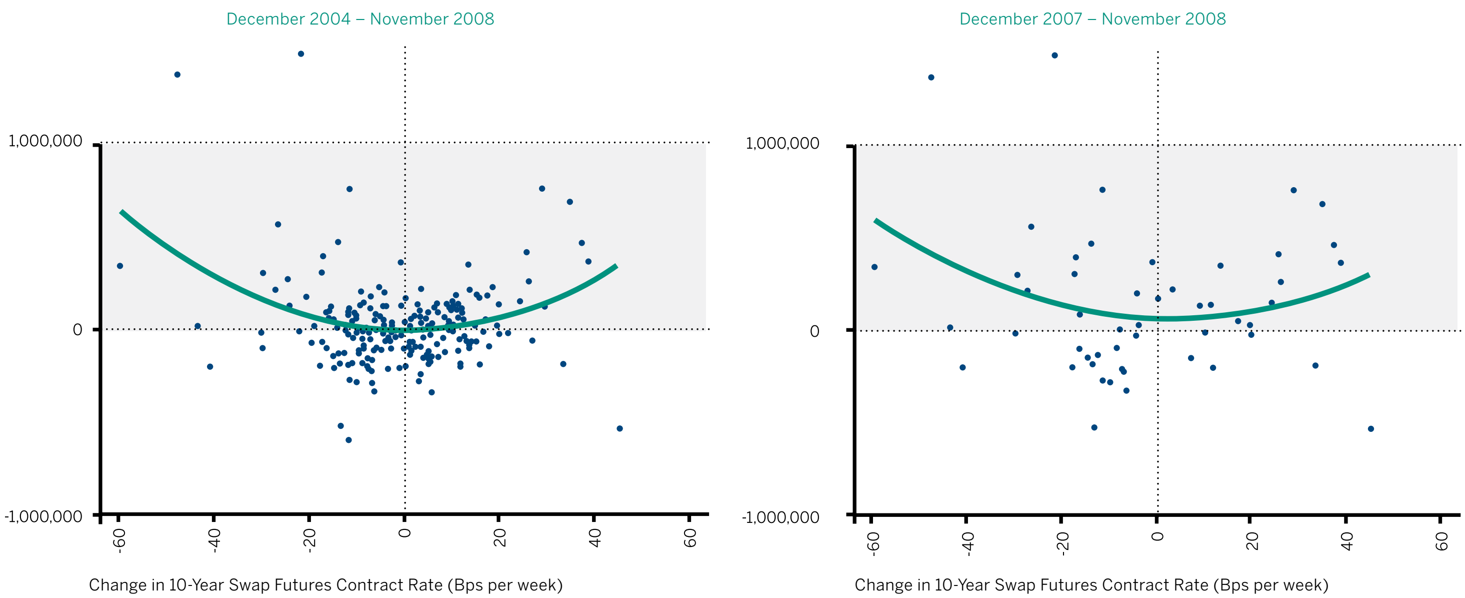
- The yield-to-price relationship for Swap futures is, by design, convex in much the same way as a bond paying fixed semiannual coupons. (To see this, check the Swap futures price formulae that appear in the Appendix.) The contract DV01 gets larger as the underlying reference swap rate falls, and it gets smaller as the underlying swap rate increases.

- By contrast, the ED futures yield-to-price relationship is famously non-convex. A Eurodollar futures contract pays its holder $25 per basis point move, regardless of whether the rate is rising or falling, regardless of whether the futures contract expires a week from now or 10 years from now. For those unfamiliar with the non-convexity bias in ED futures contract rates, the magisterial presentation is in Chapter 7 of *The Eurodollar Futures and Options Handbook* by Galen Burghardt (co-published, CME Group and McGraw-Hill, 2003).

Exhibit 4:
A Hypothetical Swap-ED Spread Example: Long 1000 Mar09 10-Year Swap Futures
Short 895 ED Blue Packs Position Entry on January 6, 2009. Position Exit on January 13, 2009

Contract	Quantity	Entry Price	Entry Rate (Pct)	Exit Price	Exit Rate (Pct)	Price Change	P/L ($)
SRH09	1,000	127-165	2.8226	131	2.4806	111.5/32nds	3,484,375.00
EDH12	895	97.22	2.78	97.510	2.490	29	-648,875.00
EDM12	895	97.16	2.84	97.470	2.530	31	-693,625.00
EDU12	895	97.11	2.89	97.440	2.560	33	-738,375.00
EDZ12	895	97.03	2.97	97.375	2.625	34.5	-771,937.50
Blue Pack Total	3,580						-2,852,812.50
P/L ($)							631,562.50

Exhibit 5:
Swap-ED Spread P/L: Long 10-Year Swap Futures Contract Rates vs. Short ED Blue Packs
(Dollar Gains per 1,000 10-Year Swap Futures, Weekly, Wednesday to Wednesday)



Notes: The spread ratio is reset at every weekly position entry date, using DV01Swap values that correspond to Swap futures prices on the position entry date, and using ED rate betas estimated with data for the 63 business days preceding the position entry date. The convention for identifying members of the ED futures Blue Pack and the nearby Swap futures contract on any given position entry date is to assume that market participants roll from the current quarterly expiry cycle into the deferred cycle on the last business day of the month before the current cycle's expiration.

Data source: CME Group

The upshot is that for large moves in market interest rates, either up or down, the Swap futures leg of a properly balanced Swap-ED spread will tend to outperform the ED futures leg. In this connection, two points are worth noting:

- First, it is reassuring to observe the persistence of the convexity differential's impact upon the P/L profile. It manifests in broadly the same form during the tumultuous year ending with November 2008 as it does for the entire four-year interval ending November 2008. (Note, however, that the U-shaped P/L profile sits higher during 2008 than it does for 2004-08. This is unsurprising, given that market participants who were long volatility would have reaped relatively greater benefits during 2008.)

- Second, there is much more to the Swap-ED spread than just the convexity differential. To the extent that the quadratic regression fits in Exhibit 4 offer any indication, the convexity differential accounts for around 10 percent of the variability in the relationship between P/L and yield changes.

Appendix: Interest Rate Swap Futures Delivery Method

Interest Rate Swap futures are settled in cash. The final settlement value, measured in price basis points, is determined as follows:

5-Year	$100 * [\ 6/r_5 + (1 - 6/r_5) * (1 + r_5/200)^{-10}\ ]$
7-Year	$100 * [\ 6/r_7 + (1 - 6/r_7) * (1 + r_7/200)^{-14}\ ]$
10-Year	$100 * [\ 6/r_{10} + (1 - 6/r_{10}) * (1 + r_{10}/200)^{-20}\ ]$
30-Year	$100 * [\ 6/r_{30} + (1 - 6/r_{30}) * (1 + r_{30}/200)^{-60}\ ]$

r_5 , r_7 , r_{10} and r_{30} represent, respectively, ISDA Benchmark Rates for 5-year, 7-year, 10-year and 30-year U.S. dollar interest rate swaps on the last day of trading, expressed in percent terms (e.g., if the ISDA Benchmark Rate were five and a quarter percent, then r would be 5.25). Contract expiration price will be the final settlement value rounded to the nearest one quarter of one thirty-second of one point.

Getting the Swap-ED spread ratio

Consider a long position in Swap futures, offset by a corresponding short position in ED futures. The profit and loss (P/L) is:

$$P/L = DV01_{Swap} * \Delta r \ - H * DV01_{ED} * \Delta i$$

In words, P/L is the difference between the net gain on the Swap futures leg and the net gain on the ED futures leg. For each leg, net gain is the product of two factors: the DV01, or the dollar value of change in the futures contract price per 1-basis-point move in the reference interest rate ($DV01_{Swap}$ for the Swap futures contract, and $DV01_{ED}$ for the Eurodollar futures); and the change in interest rates over the life of the trade (Δr for the change in the fixed swap rate referenced by Swap futures, and Δi for the forward 3-month LIBOR referenced by the ED futures).

Central to the trade is the spread ratio, H. The objective in choosing it is to insulate P/L from uniform changes in the general level of interest rates, so that the spread position generates profit or loss only if the two contract rates move by different amounts. With this in mind, suppose the dynamics of the forward 3-month LIBOR rate *i* can be broken into two pieces. One is related to the dynamics of the long-term swap rate *r*. The other reflects the spread between the two:

$$\Delta i = ß * \Delta r + \Delta Spread$$

ß is the "rate beta" that allows for the possibility that the ED futures contract may be systematically more or less volatile than the Swap futures contract rate. (Clearly, if ß is equal to 1, then the two rates would be expected to move in lockstep, basis point for basis point.) Substituting this into the P/L expression above gives:

$$P/L = [DV01_{Swap} - H * DV01_{ED} * ß] * \Delta r$$
$$- H * DV01_{ED} * \Delta Spread$$

In words, P/L arises from two sources: changes in the general level of interest rates, as reflected in the swap rate *r*, and changes in the spread between spread between forward 3-month LIBOR and the swap rate. For the spread trader's purposes, the first of these influences is unwelcome. The only way to immunize the trade against outright yield movements is to make the bracketed term – the one that includes the spread ratio H – equal to zero. We achieve this by setting the hedge ratio as:

$$Spread\ Ratio = DV01_{Swap} / (DV01_{ED} * ß)$$

This is just the ratio of the Swap futures' interest rate sensitivity to the ED futures' interest rate sensitivity, with the ED futures scaled by the relative volatility – the rate beta – of forward 3-month LIBOR versus the forward-starting swap rate.

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