CME Group

INTEREST RATES

Can Large Pension Funds Use Derivatives to Effectively Manage Risk and Enhance Investment Performance

CASE STUDY: KEY RATE DURATION ADJUSTMENT

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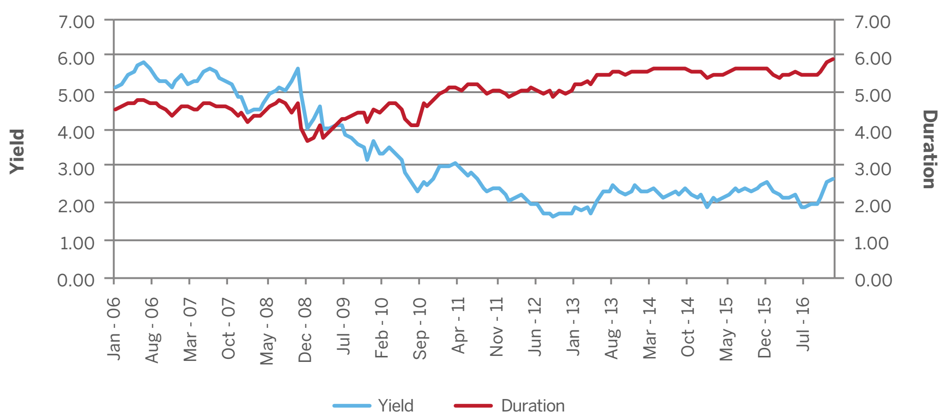
BACKGROUND

When traders and risk managers evaluate a security or portfolio's sensitivity to changes in interest rates, they usually refer to two measurements: 1) basis point value, sometimes expressed as BPV, VBP, and DV01, which measures the financial change to a 0.01% change in yield or 2) modified duration, sometimes referred to as duration, which expresses the financial change expressed in percentage change to a 1% change in yield. For example, a security could have a basis point value of $646 per million and a modified duration of 6.501 years. If the yield to maturity of this security rose from 2.36% to 2.37% it is said to have gone up by 1 basis point (0.01%) and the financial change to the holder would be a loss of $646 per million. If that same security's yield rose to 3.36%, or 1.00% (100 basis points) the security's financial change would be a loss of approximately 6.501% in value.

Most portfolio managers (PM) tend to evaluate their exposure to interest rate risk using duration. Additionally, they are frequently evaluated by how well or poorly their management of the fixed income portfolio performs versus a recognized benchmark or index. PMs routinely monitor and adjust their portfolio's target duration either to maintain an alignment to a benchmark or for tactical trading reasons.

One consequence of the long bull market in interest rates is the steady extension of portfolio and benchmark bond index duration. Even if positions are left unchanged the gradual and steady rise in bond prices resulting from historically low global interest rates causes the duration of portfolios and benchmark indices to "creep" out to higher levels.

Chart 1: Barclays Aggregate: Yield and Duration



Source: Bloomberg

The chart above shows the gradual decline in average yield and increasing level of duration of the Barclays Aggregate Bond Index, one of the most referenced benchmarks for fixed income portfolio managers. Beginning in 2009 with interest rates moving sharply lower (blue line) notice the diverging increase in duration (red line). One consequence of higher duration portfolios in an historically low interest rate environment is the "break-even" rate, or the interest rate at which the portfolio produces zero return, moves lower and closer to current interest rate levels. For example, one global bond benchmark is the Citi World Government Bond Index (WGBI). According to the November 2016 report Citi marks the North American (largely USD) average yield-to-maturity of the index at 1.79% and its duration at 6.10 years. The break-even rate (B/E) is defined as YTM (in basis points) divided by the duration (in years). In this example it would look like this: B/E = 179 / 6.10 = 29.3 bps.

In other words if interest rates were to rise by 29.3 bps over the next 12-months the portfolio's return for the year would be zero. Any interest rate move higher than 29.3 bps would result in a negative annual return on the portfolio.

PMs have many ways to modify their portfolios to adjust the target duration. They can buy and sell securities and move weightings up or down the maturity curve. This takes time and can be expensive given transaction and market impact costs. An alternative is to use US Treasury futures and options traded and cleared at CME Group to effectively adjust key rate duration (KRD) targets across the entire portfolio.

CASE STUDY #1: KEY RATE DURATION ADJUSTMENT USING FUTURES

Assume you are a portfolio manager (PM) with $10 Billion exposure to U.S. interest rates. The portfolio is diversified across the yield curve according to the maturity allocations of the WGBI.

If provided with the current portfolio and the new benchmark weightings can the PM use CME Group U.S. Treasury futures to adjust the portfolio closer to the benchmark, or some other tactical duration target?

Table 1

Tranche	Yield	Modified Duration (years)	DV01 (per $1mm face value)	Position (in $1mm face value)	Aggregate DV01
1-3 years	0.591%	2.16	$218.80	2,375	$519,650
3-5 years	0.905%	4.51	$457.10	1,950	$891,345
5-7 years	1.188%	6.37	$652.60	1,325	$864,695
7-10 years	1.374%	8.45	$916.30	1,375	$1,259,912
10+ years	2.042%	18.24	$2,222.00	2,975	$6,610,450
		8.82		$10 billion	$10,146,052

Theoretical data

The table above shows the current portfolio. The table below shows the targeted duration of the benchmark and the change needed to the portfolio.

Table 2

Tranche	Benchmark Duration	Duration Adjustment
1-3 years	1.92	-0.111
3-5 years	3.85	-0.146
5-7 years	5.66	-0.111
7-10 years	7.91	-0.064
10+ years	16.24	-0.110
	7.81	

Source: Citigroup Index LLC. Data as of 11/30/2016

In order to determine the proper hedge ratio per futures contract we need more information about the values attributed to CME Group's U.S. Treasury futures.

Table 3: CME Group CTD Analysis

U.S. Treasury Contract	CTD Issue (Dec-2016 contracts)	Modified Duration (CTD)	DV01 (per contract $100K)
2-Year	1-3/8% 9/30/2018	1.80	$39.15*
5-Year	1-1/8% 2/28/2021	4.11	$48.64
10-Year	2-1/2% 8/15/2023	6.10	$76.75
Ultra 10-Year	1-5/8% 5/15/2026	8.66	$116.18
Long Bond	5% 5/15/2037	13.89	$209.89
Ultra Bond	3-1/8% 2/15/2042	17.22	$277.38

**adjusted for 2-Year Note $200,000 notional amount*

Source: Bloomberg, and CME Group

Now that we have more information about the futures contracts we can begin to calculate our key rate duration (KRD) adjustment bringing our current portfolio into closer alignment to the desired benchmark.

Typically a futures hedge ratio (HR) is defined as the value at-risk divided by the value of the futures contract. In this example the value at-risk is the individual tranche Aggregate DV01 (basis point value or dollar value of a 0.01%) shown in the last column of Table one. The values for each futures contract are shown in the last column of Table three above. If we were constructing a simple HR with futures the equation might look like this:

HedgeRatio (HR) = $BPV_{risk} \div BPV_{contract}$.

But in this exercise, we take an additional step of adjusting the duration target for each tranche of the portfolio to bring it into alignment with the benchmark. This requires adding a duration adjustment factor to our simple hedge ratio equation. The duration adjustment factor can be expressed as:

Duration adjustment (DA) = $(D_{target} - D_{current}) \div D_{current}$.

We will include the DA factor in the adjusted hedge ratio calculation for each tranche.

Table 4

Tranche	Dcurrent	Dtarget	Dadjustment	Aggregate DV01
1-3 years	2.16	1.91	-0.111	$519,650
3-5 years	4.51	3.85	-0.146	$891,345
5-7 years	6.37	5.66	-0.111	$864,695
7-10 years	8.45	7.91	-0.064	$1,259,912
10+ years	18.24	16.24	-0.110	$6,610,450
	8.82	**7.81**		**$10,146,052**

Now with all of inputs available we calculate our adjusted hedge ratio per tranche as:

HR = (BPVrisk ÷ BPVcontract) x DA

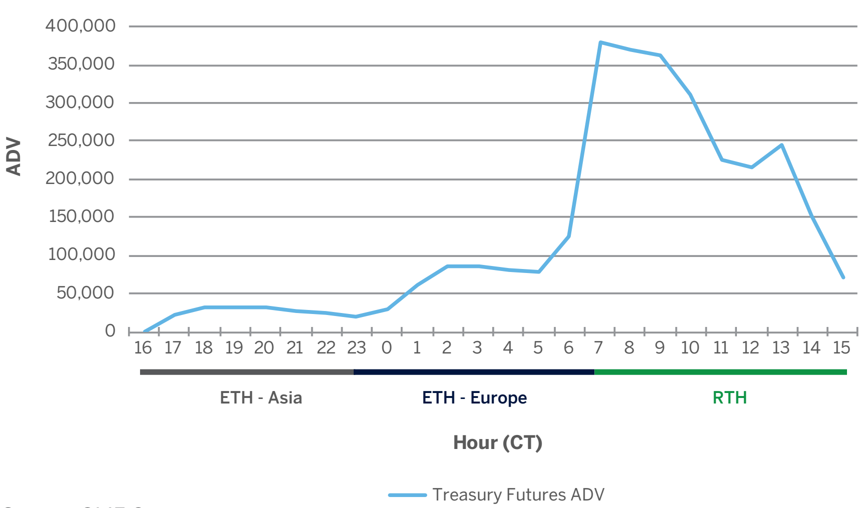
Table 5

Tranche	BPV risk	BPV contract	DA factor	HR = (Risk ÷ contract) x DA	Contract (Globex code)
1-3 years	$519,650	$39.15	-0.111	**-1,473**	ZT
3-5 years	$891,345	$48.64	-0.146	**-2,576**	ZF
5-7 years	$864,695	$76.75	-0.111	**-1,251**	ZN
7-10 years	$1,259,912	$116.18	-0.064	**-694**	TN
10+ years	$6,610,450	$277.38	-0.110	**-2,621**	ZB

Simply apply this calculation for each tranche and round to a whole number. Notice the results in the fifth column of the table above. Each result is a negative number. This shows us the duration is being adjusted lower from the current level to the new lower target level. In this case the negative number also denotes selling of futures contracts. For example, to adjust the 1-3 year tranche the PM would sell 1,473 U.S. Treasury Two-Year Note (ZTZ6) contracts. By placing all of these hedge positions versus the physical positions in the portfolio the PM effectively reduces the portfolio's duration to the benchmark or new target levels. Also the same approach can be used to express tactical views on interest rates. In this example we reduced the portfolio's duration by selling U.S. Treasury futures. We could just as easily added duration by buying futures contracts if that fits with a tactical trading decision.

Referring to Chart 2 below one can see a key benefit of using CME Group U.S Treasury futures as a duration adjustment tool is the deep pool of actionable liquidity available to traders, even during non-U.S. trading hours. The duration adjustment hedge ratios above are of a scale easily executed on CME Globex even during Asian and European trading hours. Additional benefits of this type of overlay strategy include ease of execution and lower transaction costs of futures over physical bonds.

Chart 2: Q416 Treasury Futures Hourly ADV



Source: CME Group

CASE STUDY #1 (CONTINUED): MARKET SIMULATION

What happens to our model portfolio under a rising interest rate environment?

Tables 1 and 5 show the unhedged portfolio and suggested hedge ratios per tranche to adjust the duration lower, in line with targeted duration of the benchmark.

The recent price/yield movements from 14 October-23 November 2016 provide a good laboratory to test our duration adjustment strategy. This time frame overlaps the U.S. general election held on November 8, 2016. The US election, especially for President, was highly contested and the outcome was unclear up to election day despite most media prognosticators pointing decidedly in one direction. When it became clear the outcome was different than expected the markets reacted swiftly with big swings in prices and volatility. US Treasury futures sold off as market expectations for higher yield drove Asian-trading zone (U.S. nighttime) volumes to new record highs. The selloff in Treasuries continued over the next couple of weeks.

Let's consider the results. To measure the impact let's use the on-the-run (OTR) 2-, 5-, 7-, 10-, and 30-year US Treasuries as surrogates for our respective portfolio tranches. Then compare the results of our model portfolio with and without the futures key rate duration adjustment.

Table 6

Tranche	OTR Treasury	10/14 Price/yield	11/23 Price / yield	Change P&L
1-3 years	0.75% 9/30/18	99-26+ / 0.837%	99-11 / 1.108%	**-$11,503,906**
3-5 years	1.125% 9/30/21	99-07 / 1.287%	96-21 / 1.851%	**-$49,968,750**
5-7 years	1.375% 9/30/23	98-19 / 1.591%	95-01 / 2.158%	**-$47,203,125**
7-10 years	1.50% 8/15/26	97-10 / 1.799%	92-16 / 2.369%	**-$66,171,875**
10+ years	2.25% 8/15/46	93-19 / 2.559%	84-18 / 3.042%	**-$268,679,688**
		Unadjusted portfolio	Total =	**($443,527,344)**

If we look at just the 10-Year OTR (7-10 years Tranche) price/yield move we see yields rose from 1.799% to 2.369% or a 57.0 bps rise over this short period. The portfolio's total loss is consistent with expectations given an average duration of 8.82 years and an average rate increase of roughly 50.0 bps. What about the futures duration adjustment hedge?

Table 7

Tranche	Contract (Globex code)	HR = (Risk ÷ contract) x DA	10/14 Price	11/23 Price	Change P&L
1-3 years	ZT	**-1,473**	109-01	108-19+	$5,753,906
3-5 years	ZF	**-2,576**	120-26+	118-11	$6,399,750
5-7 years	ZN	**-1,251**	129-27+	125-11+	$5,629,500
7-10 years	TN	**-694**	141-29+	135-01+	$4,771,250
10+ years	ZB	**-2,621**	176-19	161-29	$38,495,937
				Total =	$61,050,343

($443,527,344) + $61,050,343 = ($382,447,001) net loss.

This is reasonable considering the $382.5 million dollar net loss represents roughly a 7.64 year duration (versus a target of 7.81 years) resulting from an approximately 50.0 bps rise in rates. The futures hedge effectively reduced the portfolio's duration by 1-year reducing portfolio losses by $61 million.

How much capital was required to open and maintain the futures adjustment hedge? Exchange operators like CME Group require performance bond or "margins" to secure and maintain open futures positions.

Table 8

Contract (Globex code)	HR = (Risk ÷ contract) x DA	Initial margin Per contract*	Initial capital requirement
ZT	**-1,473**	$660	$972,180
ZF	**-2,576**	$935	$2,408,560
ZN	**-1,251**	$1,595	$1,995,345
TN	**-694**	$2,420	$1,679,480
ZB	**-2,621**	$6,160	$16,145,360
		Total =	$23,200,925

**Margins set by and subject to change without notice by CME Clearing.*

The total capital needed to open the futures duration adjustment hedge was a little more than $23 million. If rates fell and the hedge positions remained in place additional funds might be required to keep the futures positions in place. The additional funds are the result of variation margin, required as the market moves against the open positions.

As demonstrated, US Treasury futures can be used to effectively adjust a large bond portfolio's duration to align with a benchmark or for tactical trading reasons. CME Group US Treasury futures trade actively 23-hours per trading day giving risk managers access to liquidity even during non-U.S. trading hours. Because market-shaping events can occur at any time of the global 24-hour day, it is important to have access to liquidity around the clock.

Is this the only way to hedge or modify an existing position subject to interest rate risk? No. Let's now consider options on US Treasury futures and two simple strategies to help manage rising interest rate risk.

CASE STUDY #2: HEDGING INTEREST RATE RISK WITH OPTIONS, LONG SINGLE PUT

Let's go back to the same market conditions in Case #1 but instead of utilizing only futures to adjust KRD for the portfolio we will use some options on US Treasury futures available through CME Group.

Options are attractive to both risk managers and traders because unlike futures which respond to changes in price in a linear fashion, options exhibit an asymmetrical risk/reward profile. That is, if one is buying options one's risk is limited to the premium paid but the potential rewards are theoretically endless. Due to the dynamic aspects of how long option positions respond to favorable price movements in the underlying their value increases at an increasing rate much like convexity in bonds. Price volatility contributes to an option's premium so when market volatility rises it has a favorable impact on a long options position.

For illustrative purposes we will take one tranche of our portfolio and consider the effects of substituting an options position in place of futures. Looking at 5-7 year tranche we previously adjusted the target duration using 10-Year futures (Globex symbol ZN). We calculated a hedge ratio of selling 1,251 contracts to adjust the portfolio's key rate duration lower to help manage the risk of rising interest rates. Now assume the PM is interested in buying rising rate protection using out-the-money (O-T-M) puts on US Treasury 10-Year notes. Our PM targets a rate rise of 50.0 bps from current (Oct 14) levels as a risk target.

The first step is to identify a futures price level that roughly corresponds with a 50.0 bps move in rates. Understanding how CME Group US Treasury futures price is essential to this step. Normally we would consult a pricing model or spreadsheet and input the appropriate changes to solve for the revised price level. There are software and market data providers, like Bloomberg for example, that have analytical tools to provide this function. Using a CME Group model we calculate a December Ten-year note futures price of 125-25. The nearest O-T-M strike, also for December expiry (on November 25, 2016) is the 126-00 put.

Looking into the December 10-Year Note 126 put on October 14 we find the following:

Table 9

Option	Price	Delta	Gamma	Theta	Vega	Volatility
Z126 Put	3	-0.05	0.0420	-0.0023	0.0436	5.36%

Data: Quikstrike and CME Group

Taking the DEC 126 put delta and our previously identified hedge ratio of futures contracts we can calculate the number of puts to buy.

Put amount = HR-in futures contracts / delta = 1,251 / 0.05 = 25,020 or

Buy 25,020 December 126 Ten-Year Note puts at .03, or 3-1/64ths. Each 1/64th is equal to $15.625 therefore the total cost and capital outlay is 25,020 x 3 x 15.625 = $1,172,813. Buying, or going long, an option (put or call) requires full payment at time of execution. It also defines the total risk of the position. For a long option holder the risk is limited to the total premium paid.

CASE STUDY #2 (CONTINUED): MARKET SIMULATION

From 14 October to 23 November 2016 the price of the December Ten-Year note futures (Globex code ZNZ6) fell from 129-27+ to 125-11+. How did the DEC 126 put perform?

Table 10

Option/Date	Price	Delta	Gamma	Theta	Vega	Volatility
Z126P-10/14	3	-0.05	0.0420	-0.0023	0.0436	5.36%
Z126P-11/23	44	-0.85	0.3787	-0.0371	0.0208	6.75%
Change	41					

Data: Quikstrike and CME Group

The price of the ZNZ6 futures fell far enough to place the DEC 126 Puts from O-T-M to in-the-money (I-T-M) and as a result greatly increased their value. As you can see from the Table ten above not only did the premium of the option increase so did its delta, gamma, theta, and volatility. The only measurement that decreased was the vega. Without going deeply into options pricing theory what needs highlighting here is the fact that a long options position conveys convexity. In other words because this was a long put option position and futures prices moved lower the magnitude of change in the delta increased with each downtick in price which contributed to the premium moving higher. Futures contracts exhibit a delta of 1.0, which means their prices change in a linear fashion. One of the benefits of a long option position is positive gamma, or convexity. The put position increased in value more than the short futures position.

To determine the profit & loss (P&L) of the option overlay take the amount (25,020) and multiply times the value of each option ($15.625) multiplied times the net change (41-1/64s)

P&L = 25,020 x 15.625 x 41 = $16,028,438

Let's compare the single put overlay to the futures overlay.

Table 11

	Single Put	Futures
Result	$16,028,438	$5,629,500
Capital outlay	$1,172,813	$1,995,345

While the results heavily favor the single option strategy it should be noted that had the price of ZNZ6 futures fallen to only 126-01 the put option would have been O-T-M and unless offset or rolled forward could have expired worthless. Both futures and options on futures have pluses and minuses regarding their usefulness as hedging tools. Let's consider another simple options strategy that could be used in this capacity.

CASE STUDY #3: HEDGING INTEREST RATE RISK WITH OPTIONS, PUT SPREAD

Another strategy that may provide effective rising rate risk coverage is a long put spread. A spread is a simultaneous purchase and sale of two options with different strikes, different months, or different types. The combination of possible spreads is almost endless. We will limit this example to a simple long put spread. Using the same risk target as the previous example (125-25) we want to "bracket" the target by buying a higher strike put and selling a lower strike put in equivalent amounts. Since 125-25 is between 125-00 and 127-00 we will buy the DEC 127 puts and sell the DEC 125 puts. How do we determine how many to buy/sell?

Table 12

Option	Price	Delta	Gamma	Theta	Vega	Volatility
Z127P-10/14	6	-0.09	0.0752	-0.0043	0.0723	5.00%
Z125P-10/14	2	-0.03	0.0258	-0.0022	0.0301	6.03%
Net	**4**	**-0.06**	**0.0494**	**-0.0021**	**0.0422**	

Since this is a spread position we are concerned with net effects of our initial position. The spread is a net debit, which means we have to pay to buy it. It also means our losses are limited to our net premium paid. The delta is net negative which implies the spread should increase in value if the underlying futures price goes down. It has positive net gamma suggesting it exhibits convexity and that the delta will increase as the underlying's price moves lower. It has a small degree of time decay and a slight degree of positive sensitivity to higher volatility. How many spreads to buy? Same ratio calculation as the single option:

Put spread amount = HR-in futures contracts / net delta = 1,251 / 0.06 = 20,850, therefore

Buy 20,850 DEC 127 puts and sell 20,850 DEC 125 puts. Using the same market dates and price data as before how did the put spread perform?

CASE STUDY #3 (CONTINUED): MARKET SIMULATION

Table 13

Option	Oct 14	Nov 23	Change
Z127 Put	6	105	99
Z125 Put	2	6	4
Net	**4**	**99**	

As you can see from the Table thirteen above the nearer out-the-money 127 puts out performed the far out-the-money 125 puts. The futures price level of 125-11+ on November 23 was in between the two strikes creating good profit potential. Let's review the numbers.

P&L = 20,850 x 15.625 x 99 = $32,252,344

Why did the put spread outperform the single put? The gamma on the 127 put was greater than the gamma of the 126 put. Additionally the short 125 put position contributed by reducing the initial cost and also lowering the net delta. The fact that the price of the underlying futures contract ended above the 125 strike reduced the drag of the short put side of the spread.

Table 14

	Put Spread	Single Put	Futures
Result	$32,252,344	$16,028,438	$5,629,500
Capital outlay*	$1,303,125	$1,172,813	$1,995,345

SUMMARY

There are clear differences among these simple strategies and many more that could be considered. We have limited our review to these few to simply illustrate the effectiveness of a key rate duration adjustment and comparing the dynamic aspects of long options positions to an equivalent straight futures hedge. What is important to remember is there is no "silver bullet", or single risk overlay strategy that works perfectly at all times. Futures and options on futures are very efficient risk management tools. Additionally, liquidity in CME Group US Treasury futures and options is deep and bid/offer spreads very tight, even during non U.S. trading hours. In order to apply the best risk management or hedging strategy it is essential to understand and quantify the underlying price risk. It is equally important to understand the pricing mechanism and trading behavior of the derivative products used to offset that risk. Global interest rates are near record low levels, with correspondingly high levels of duration in institutional portfolios and bond index benchmarks the break-even levels for fixed income risk managers is very close to current market rates. It will only take a small rise in rates to tip annualized investment returns negative. Transaction and capital charges favor the use of ETD as a duration adjustment tool. Their effective use can help large institutional asset managers manage risk and enhance returns.

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