CME Eurodollar Futures – An Introduction

CME Interest Rate Products

October 26, 2005

What are Eurodollars?

- **Markets developed in London in 1950's and 60's**
- **Time deposits denominated in U.S. dollars in commercial banks outside the U.S.**
- **Benchmark interest rate for corporate funding.**
  - **Corporations borrow with "floating" rate plus credit spread**
- **Also known as London Interbank Offered Rate – LIBOR**
- **Succeeded "Prime Rate" in the late 70's and early 80's**

CME Eurodollar Futures

- **CME 3-Month Eurodollar Futures**
  - **Most actively traded short-term interest rate contracts in the world**
    - **Launched December 1981**
    - **On September 15, 2005 open interest in the Eurodollar futures and options contract reached record levels of 29.7 million contracts**
  - **Grew with development of the interest rate swap market over the last 20+ years**

CME Eurodollar Futures (Continued)

- **CME 3-month Eurodollar Futures** (Continued)
  - **Most active users:**
    - **Bank asset/liability managers**
    - **Interest rate swap dealers**
    - **Local traders in Chicago**
    - **Proprietary traders**
    - **Hedge funds**
  - **New Developments:**
    - **Over 80% of Eurodollar futures volume is electronic**

CME Eurodollar Futures Specifications

- **CME Euro$ futures contracts are traded using a price index derived by subtracting the futures' interest rate from 100.00. (100- r = Eurodollar Price)**
- **Rate represents interest on a 3-month Eurodollar deposit of $1 million.**
- **Prices denominated in ¼, ½ or 1 basis point increments (1 basis point = $25)**
  - **$25 = $1,000,000 x .0001 x 90/360**
- **Mar, Jun, Sep, Dec contracts listed out 10 years (a total of 40 contracts) including four serial futures (Oct, Nov, Jan, Feb)**
- **Futures expire Second London bank business day prior to the third Wednesday of the contract month**
- **Futures are cash settled at expiration to daily British Bankers' Association survey of 3-month LIBOR**

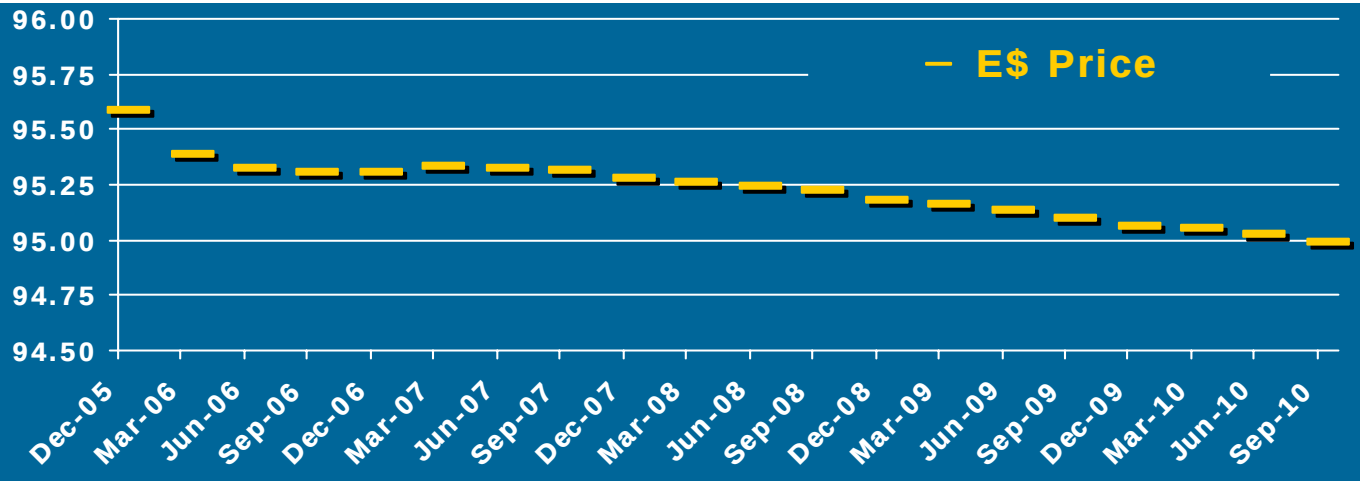
Eurodollar Mechanics – Outrights, Spreads & Strips

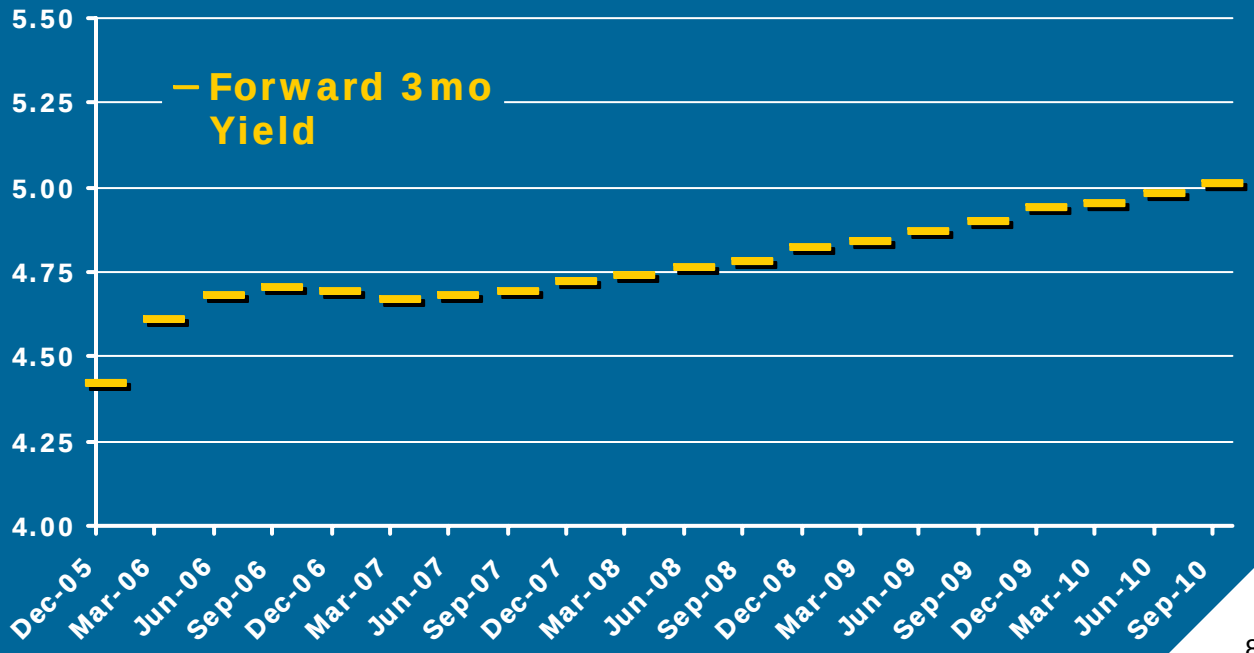
- Outrights
  - Years 1 – 10, quarterly
- Spreads
  - Simultaneous purchase and sale of contracts in different months
  - Spread traders provide the bulk of liquidity in the front eight Eurodollar contracts
- Strips
  - The purchase or sale of two or more consecutive quarterly futures expirations

Packs & Bundles are "pre-packaged" Strips

- Facilitate rapid execution of specific Strips with a single transaction
- Bundles
  - 2-10 year packages of consecutive futures contracts
  - Always begin with the front quarterly contract
  - Quoted in ¼ basis point (.25) price increments
  - Priced on the basis of average net change of each individual contract from previous day's settlement price
- Packs
  - 10 specific packages of 4 consecutive futures contracts
  - Quoted in ¼ basis point (.25) price increments
  - Priced similarly to Bundles
  - Designated by color codes that correspond to their position on the yield curve: White, Red, Green, Blue, Gold, Purple, Pink, Silver and Copper

Eurodollar Pricing





Deriving Eurodollar Forward Rates

Implied forward rates

- **Eurodollar futures reflect market expectations of forward 3-month rates. An implied forward rate indicates approximately where short-term rates may be expected to be sometime in the future. The following formula provides a guideline for calculating a 3-month rate, three months forward:**

1 + 6mth spot rate x 182/360 =

(1 + 3mth spot rate x 91/360) x (1 + 3mth fwd rate x 91/360)

Deriving Eurodollar Forward Rates (Continued)

Implied forward rates: Example

- 3-month LIBOR spot rate = **3.7800%**
- 6-month LIBOR spot rate = **4.0248%**
- 3-month forward rate = **R**

Solve for R:

1. 1 + .040248 x 182/360 = (1 +.0378 x 91/360)(1 + R x 91/360)

2. 1.020348 = (1.009555)(1 + R x 91/360)

3. 1.010690 = (1 + R x 91/360)

4. 0.042292 or **4.23%** = R = the implied forward rate

Deriving Eurodollar Forward Rates (Continued)

Implied forward rates:

	90-Day Rate	180-Day Rate	Implied Forward Rate
Steep Yield Curve	3.75 %	4.00 %	4.21 %
Inverted Yield Curve	3.75 %	3.50 %	3.22 %
Flat Yield Curve	3.75 %	3.75 %	3.71 %

Eurodollar Yield Curve Spreads

Calendar or Yield Curve spreads are one of the most common Eurodollar trades at CME

- **Since the value of 1 basis point is $25 in the quarterly Eurodollar futures, the ratios for Yield curve spreads are 1:1**
- **Steepening Yield Curve Strategy**
  - **Buy the shorter maturity Eurodollar Future; sell the longer maturity Eurodollar Future**
- **Flattening Yield Curve Strategy**
  - **Sell the shorter maturity Eurodollar Future; buy the longer maturity Eurodollar Future**

Eurodollar Yield Curve Spreads (Continued)

Why do you do one versus the other?

- **Steepening Yield Curve Strategy**
  - Market anticipates long-term interest rates will rise faster than short-term interest rates or long-term rates remain steady while short-term rates fall.
  - Reason: General perception is that economy remains weak and the Federal Reserve is expected to do either nothing or to possibly lower interest rates again.
- **Flattening Yield Curve Strategy**
  - Market anticipates short-term interest rates will rise faster than longer-term interest rates.
  - Reason: Employment news surprises market and economy is expected to strengthen further and Federal Reserve is expected to raise short-term interest rates to head off potential rise in inflation.

Eurodollar Yield Curve Spreads (Continued)

- **Steepening Yield Curve Strategy**
  - **Buy the shorter maturity Eurodollar Future; sell the longer maturity Eurodollar Future**

Date	Buy Mar '05 Eurodollar (Price)	Sell Mar '09 Eurodollar (Price)	Spread Difference
01/30/04	97.52	94.48	304 b.p.
03/30/04	98.06	94.80	326 b.p.
	+0.54	- 0.32	+22 b.p.

Yield Curve Spreads (Continued)

- Steepening Yield Curve Strategy

Results:

- **On 01/30/04, buy 100 of the Mar '05 Eurodollar futures at 97.52; sell 100 of the Mar '09 Eurodollar futures at 94.48 with yield curve spread at 304 basis points.**
- **On 03/30/04, sell off 100 of the Mar '05 Eurodollar futures at 98.06; buy back 100 of the Mar '09 Eurodollar futures at 94.80 with the yield curve spread at 326 basis points.**
- **Net gain: yield curve steepens 22 basis points for profit of $55,000 (22 b.p. x $25 per b.p. x 100 contracts)**

Eurodollar Yield Curve Spreads (Continued)

- Flattening Yield Curve Strategy
  - **Sell the shorter maturity Eurodollar Future; buy the longer maturity Eurodollar Future**

Date	Sell Mar '05 Eurodollar (Price)	Buy Mar '09 Eurodollar (Price)	Spread Difference
03/31/04	98.13	94.88	325 b.p.
06/30/04	97.03	94.26	277 b.p.
	+1.10	-0.62	- 48 b.p.

Yield Curve Spreads (Continued)

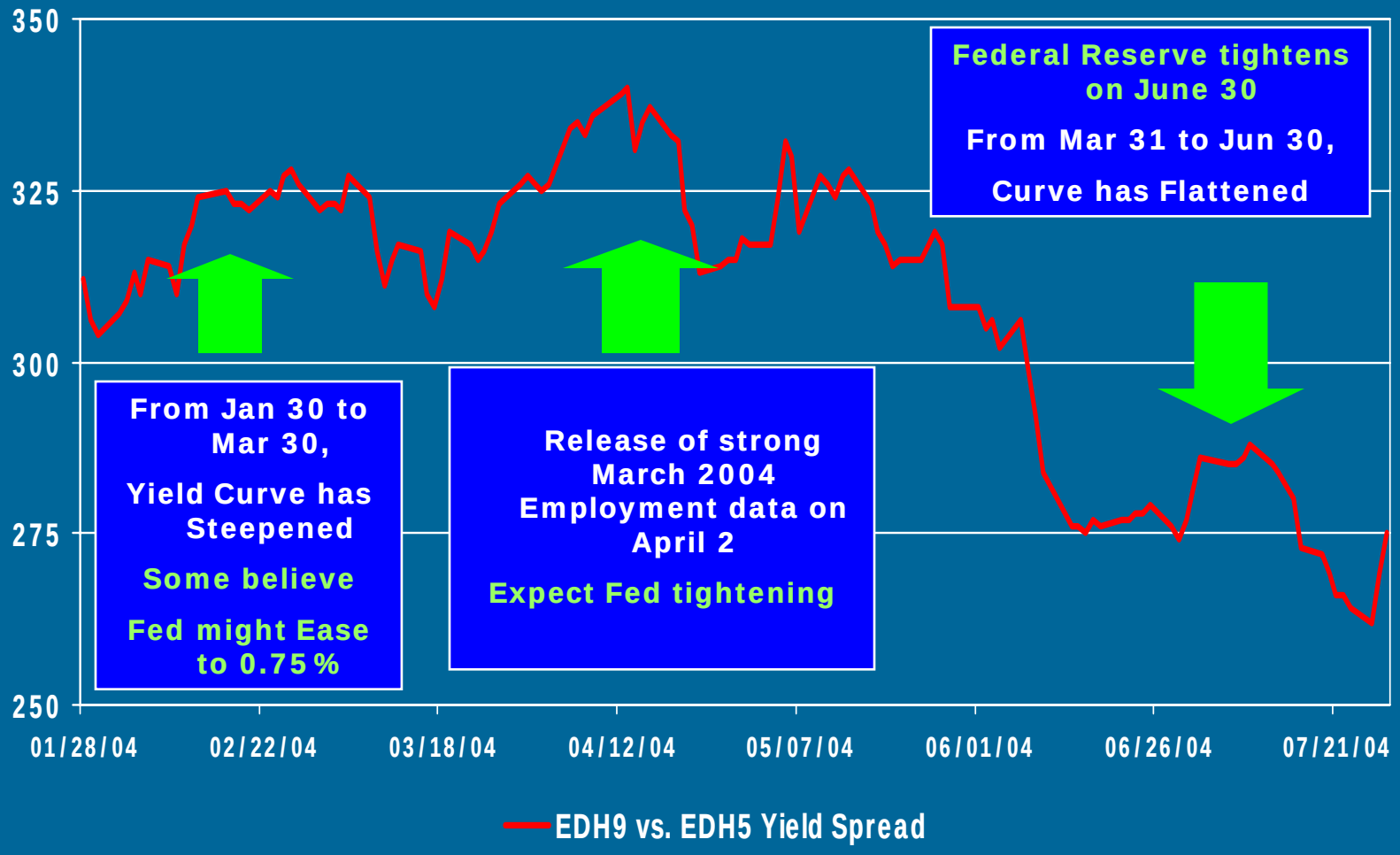
- Flattening Yield Curve Strategy

Results:

- **On 03/31/04, sell 100 of the Mar '05 Eurodollar futures at 98.13; buy 100 of the Mar '09 Eurodollar futures at 94.88 with yield curve spread at 325 basis points.**
- **On 06/30/04, buy back 100 of the Mar '05 Eurodollar futures at 97.03; sell off 100 of the Mar '09 Eurodollar futures at 94.26 with the yield curve at 277 basis points**
- **Net gain: Yield curve flattens 48 basis points for profit of $120,000 (48 b.p. x $25 per b.p. x 100 contracts)**

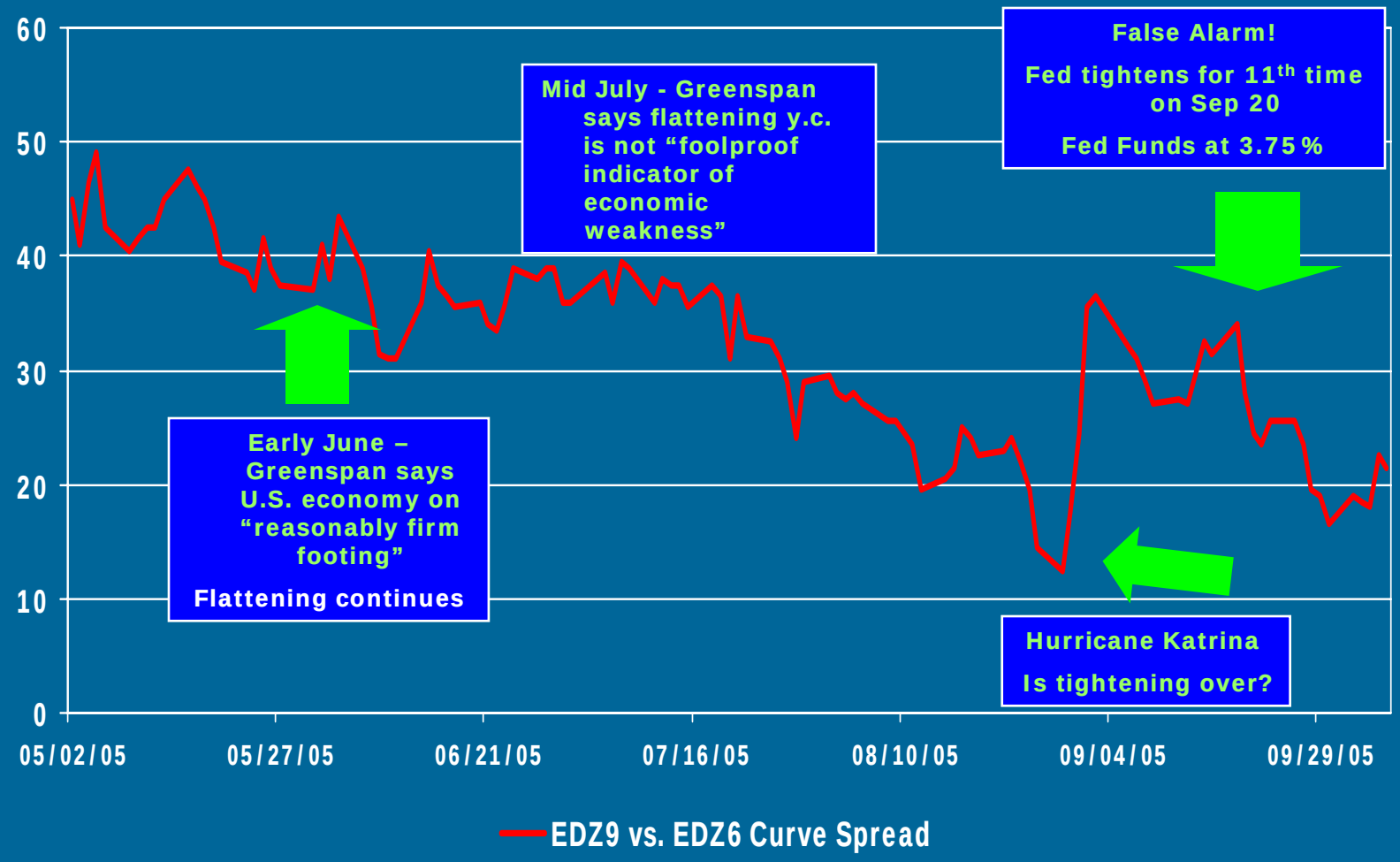
Yield Curve Spreads (Continued)

- **Yield Curve (2004)**



Yield Curve Spreads (Continued)

- **Yield Curve (2005)**



Eurodollar Butterfly Curve Spreads

Butterfly spreads are basically two calendar spreads, back-to-back

- They are often executed in this fashion—one spread at a time-or they may be done as a package on GLOBEX
- **Ratio is 1:2:1**
  - First Wing - 1 contract – first Eurodollar expiration
  - Body - 2 contracts – second Eurodollar expiration
  - Second Wing - 1 contract – third Eurodollar expiration

Eurodollar Butterfly Spreads (Continued)

Butterfly spreads (Continued)

- **Long Butterfly**
  - Buy the nearby wing (1 time) / Sell body (2 times) / Buy the deferred wing (1 time)
  - Gains if the spread widens or gets more positive (less negative)
- **Short Butterfly**
  - Sell the nearby wing (1 time) / Buy body (2 times) / Sell the deferred wing (1 time)
  - Gains if the spread narrows or gets less positive (more negative)

Eurodollar Butterfly Spreads (Continued)

Butterfly spreads (Continued)

- **Year butterfly spread over time in 2004**

Date	Dec 2004 Price	Diff.	Dec 2005 Price	Diff.	Dec 2006 Price	Butterfly Spread [(EDZ4-EDZ5)-(EDZ5-EDZ6)]
Mar 31, 2004	98.43	1.25	97.18	0.94	96.24	+ 0.31 b.p. Buy Z4-Z5-Z6 Butterfly
Jun 30, 2004	97.48	1.47 + 0.22	96.01	0.74 + 0.20	95.27	+ 0.73 b.p. Trade Gains 0.42 b.p.; then Sell Z4-Z5-Z6 Butterfly
Sep 20, 2004	97.79	0.92 + 0.55	96.87	0.73 - 0.01	96.14	+ 0.19 b.p. Trade gains 0.54 b.p.

Eurodollar Butterfly Spreads (Continued)

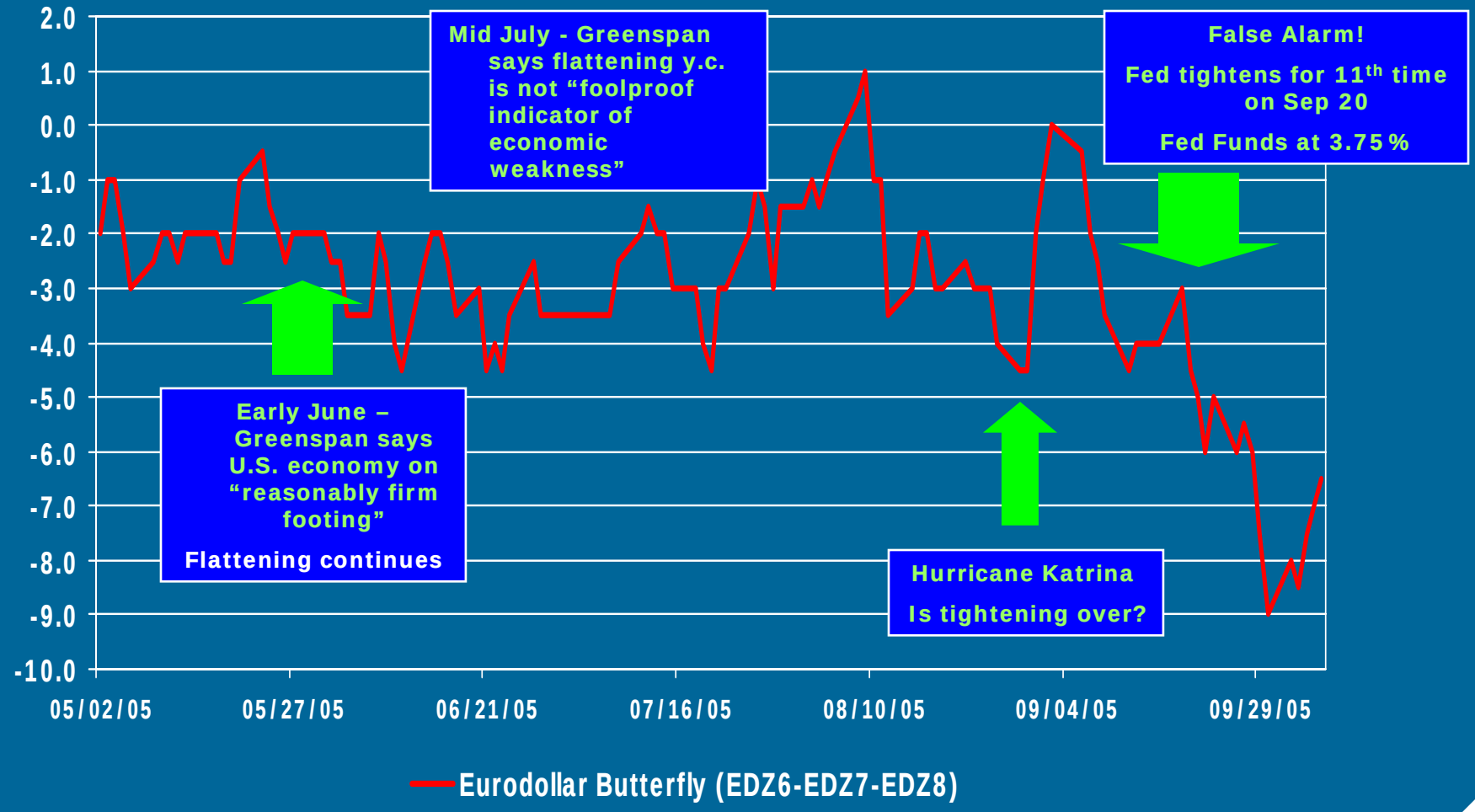
Butterfly spreads (Continued)

- **Year butterfly spread over time in 2005**

Date	Dec 2006 Price	Diff.	Dec 2007 Price	Diff.	Dec 2008 Price	Butterfly Spread [(EDZ6-EDZ7)-(EDZ7-EDZ8)]
Jun 6, 2005	95.935	0.095	95.840	0.130	95.710	- 0.035 b.p. Buy Z6-Z7-Z8 Butterfly
Aug 9, 2005	95.355	0.085 - 0.01	95.270	0.075 + 0.055	95.195	+ 0.010 b.p. Trade Gains 0.045 b.p.; then Sell Z6-Z7-Z8 Butterfly
Sep 27, 2005	95.495	0.030 + 0.055	95.465	0.085 + 0.01	96.380	- 0.055 b.p. Trade gains 0.065 b.p.

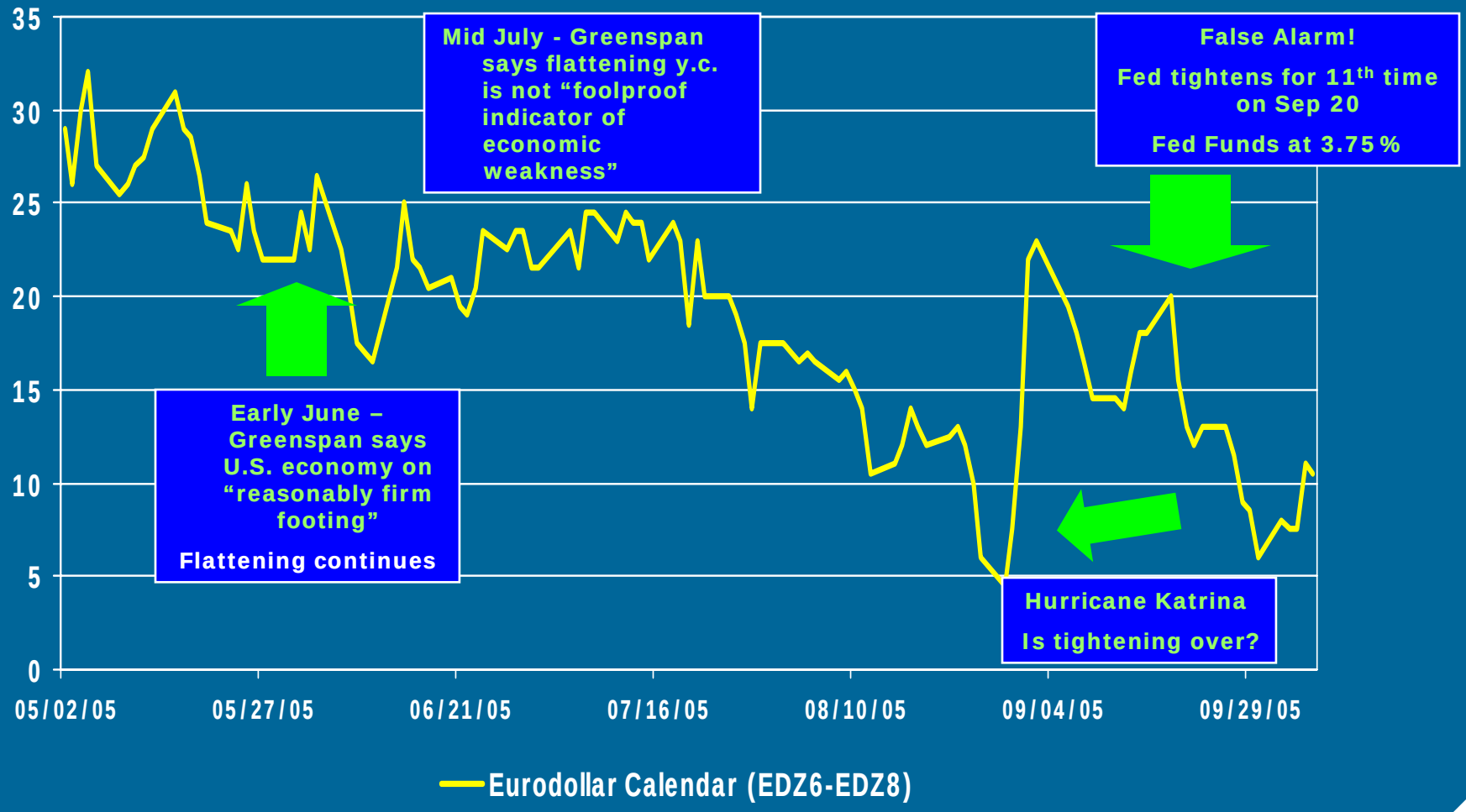
Eurodollar Butterfly Spreads (Continued)

- **Butterfly Spreads – Recent History (EDZ6-EDZ7-EDZ8)**



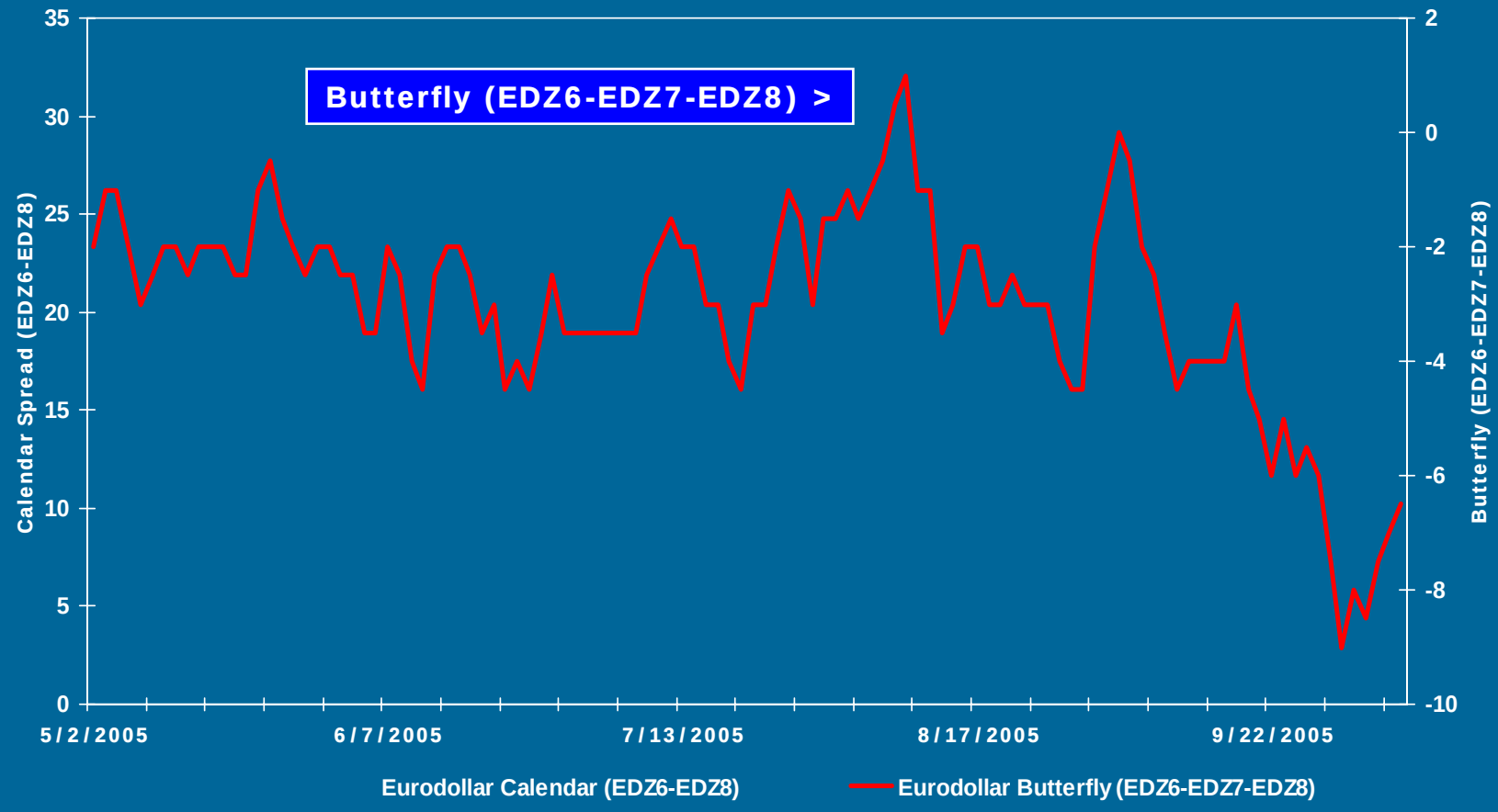
Eurodollar Butterfly Spreads (Continued)

- **Calendar Spreads – Recent History (EDZ6-EDZ8)**



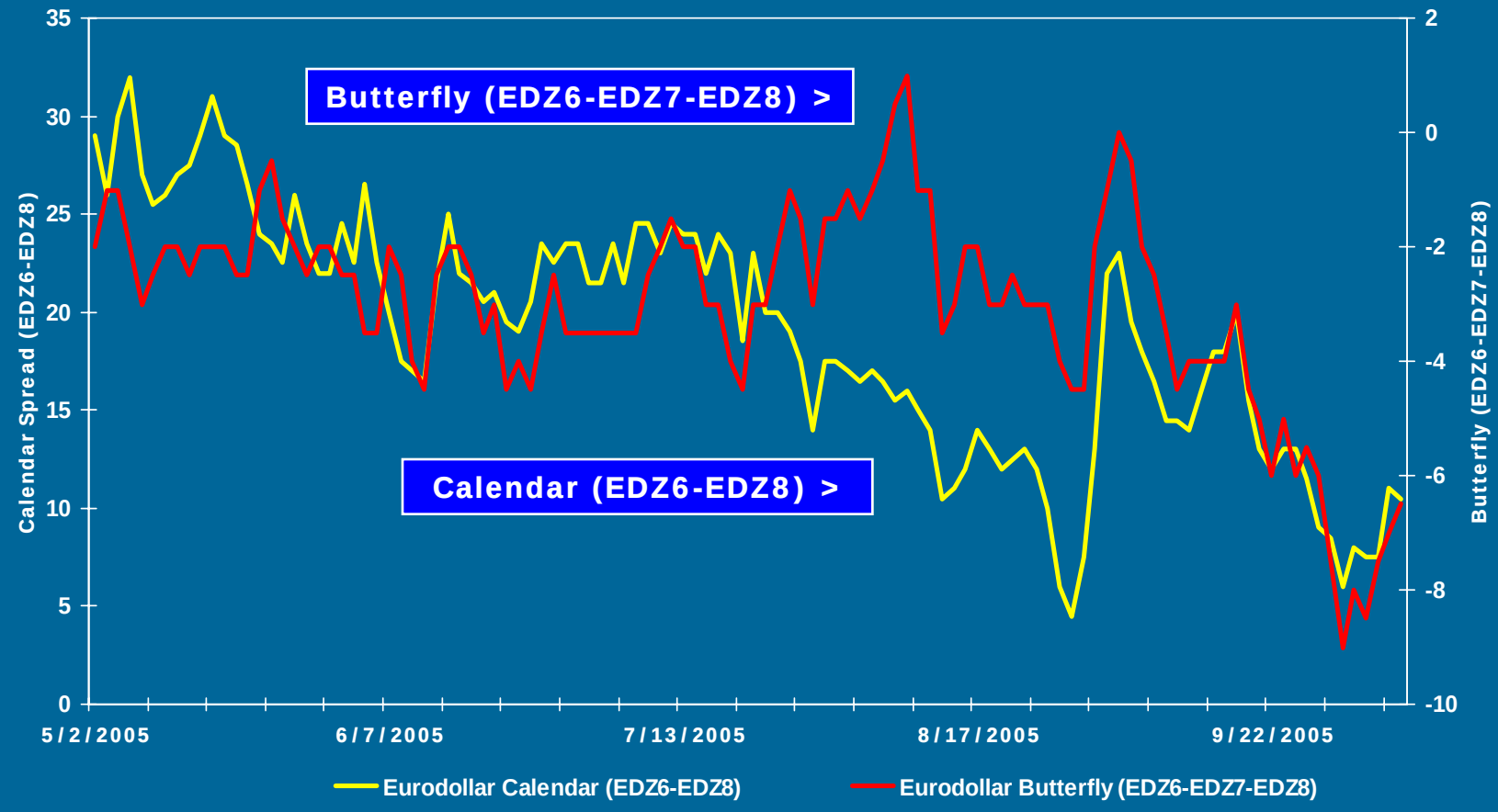
Eurodollar Butterfly Spreads (Continued)

- **Overlay of Calendar Spreads (EDZ6-EDZ8) / Butterfly (EDZ6-EDZ7-EDZ8)**



Eurodollar Butterfly Spreads (Continued)

- **Overlay of Calendar Spreads (EDZ6-EDZ8) / Butterfly (EDZ6-EDZ7-EDZ8)**



Interest Rate Swap Market

Interest rate swap (IRS) transaction …

- **Exchange a series of fixed rate payments for floating rate payments based on a specified amount of principle**
  - **Fixed rate payer "buys" or is "long" … floating rate payer "sells" or is "short" the IRS**

- **"Vanilla" swap generally tied to 3- or 6-month LIBOR rates**
  - **An "IMM-dated" swap has floating rate reset dates that match expirations of CME Eurodollar futures but reset dates may be negotiated**
  - **The term or "tenor" of a swap may vary from 1-10+ years**

Interest Rate Swap Market

Quoting an IRS …

- **Swap generally quoted as fixed rate while floating rate generally tied to 3- or 6-month rate, *e.g.,* LIBOR**
- **Periodic payments generally netted**
  - **$10 mil IRS is quoted at 4.25% vs. flat 6-month LIBOR**
  - **182 days to 1st payment date when 6-month LIBOR at 3.75%**

Fixed Payment (R_{fixed})	=	$10,000,000 x 0.0425 x (180/360)	=	$212,500
Floating Payment ($R_{floating}$)	=	$10,000,000 x 0.0375 x (182/360)	=	$189,583
		Net Payment	=	$22,917

- **Pricing an IRS**
  - **Fair value of a swap is such that present values of fixed and floating payments are balanced … $PV_{fixed} = PV_{floating}$**

Pricing Swaps with CME Eurodollar Futures

Cash flow analysis ...

- **Fair value of a swap is such that present values of fixed and floating payments are balanced ...**
  $PV_{fixed} = PV_{floating}$
- **Consider IMM-dated swap ...**

$$\sum_{i=1}^{n} PV_i \, (R_{fixed} / 4) \, P \quad = \quad \sum_{i=1}^{n} PV_i \, R_i \, (d_i / 360) \, P$$

- **WHERE: P = Principle**
  - **PV_i = Present value of $1 received i days ($d_i$) in future**
  - **R_i = 3-month LIBOR rate expected to prevail d_i days in future**
- **Solving for fixed rate R_{fixed} ...**

$$R_{fixed} = 4 \sum_{i=1}^{n} PV_i \, R_i \, (d_i / 360) \; / \; \sum_{i=1}^{n} PV_i$$

Pricing Swaps with CME Eurodollar Futures

- **EXAMPLE: Find value of 2-year $10 mil IRS … Trade date Sep. 19, 2005 for value Sep 21, 2005**

Instrument	Expiration Date	Day Span	Price	Yield (R)	Compound Value	Discount Factor (PV)
EDU5	09/19/05	93	96.08	3.92	1.0101	0.9900
EDZ5	12/19/05	84	95.87	4.13	1.0199	0.9805
EDH6	03/13/06	98	95.77	4.23	1.0316	0.9694
EDM6	06/19/06	91	95.72	4.28	1.0428	0.9590
EDU6	09/18/06	91	95.69	4.31	1.0541	0.9487
EDZ6	12/18/06	91	95.66	4.34	1.0657	0.9384
EDH7	03/19/07	91	95.65	4.35	1.0774	0.9282
EDM7	06/18/07	91	95.63	4.37	1.0893	0.9180

$$R_{fixed} = 4\,[\,(0.9900)(0.0392)(93/360) + (0.9805)(0.0413)(84/360) + (0.9694)(0.0423)(98/360) + (0.9590)(0.0428)(91/360) + (0.9487)(0.0431)(91/360) + (0.9384)(0.0434)(91/360) + (0.9282)(0.0435)(91/360) + (0.9180)(0.0437)(91/360)\,] \div [0.9900 + 0.9805 + 0.9694 + 0.9590 + 0.9487 + 0.9384 + 0.9282 + 0.9180\,]$$

$$= 4.297\% \ (4.297033628\%)$$

- **Fixed rate calculated as 4.297033628% with fixed payment of $107,425.84 [=$10,000,000(0.04297033628 ÷ 4)]**

Pricing Swaps with CME Eurodollar Futures

- **Confirm that present values of fixed and floating payments are balanced … $PV_{fixed} = PV_{floating} = \$819,877.24$**

Valuation Date	Fixed Payments	Discount Factor (PV)	PV of Fixed Payments	Floating Payments	Discount Factor (PV)	PV of Floating Payments
12/21/05	$107,425.84	0.9900	$106,348.88	$101,266.67	0.9900	$100,251.45
03/15/06	$107,425.84	0.9805	$105,333.81	$96,366.67	0.9805	$94,490.01
06/21/06	$107,425.84	0.9694	$104,134.70	$115,150.00	0.9694	$111,622.22
09/20/06	$107,425.84	0.9590	$103,020.14	$108,188.89	0.9590	$103,751.89
12/20/06	$107,425.84	0.9487	$101,909.86	$108,947.22	0.9487	$103,353.12
03/21/07	$107,425.84	0.9384	$100,803.98	$109,705.56	0.9384	$102,943.17
06/20/07	$107,425.84	0.9282	$99,707.62	$109,958.33	0.9282	$102,058.16
9/19/07	$107,425.84	0.9180	$98,618.24	$110,463.89	0.9180	$101,407.21
			$819,877.24			$819,877.24

Hedging Swaps with CME Eurodollar Futures

Matching cash flows …

- **Balance changes in value of hedged item with change in value of futures contract**

  $$\Delta \text{ Value of Hedged Instrument} \approx \Delta \text{ Value of Futures Position}$$

- **BUT … need to measure changes in value with use of "basis point value" (BPV)**
  - **BPV measures change in the value of an instrument in response to a one basis point (0.01%) change in yield**
  - **BPV of one CME Eurodollar futures ($BPV_{futures}$) = $25.00**

$$\begin{aligned} BPV_{futures} &= FV \times (d/360) \times 0.01\% \\ &= \$1{,}000{,}000 \times (90/360) \times 0.01\% \\ &= \$25.00 \end{aligned}$$

Hedging Swaps with CME Eurodollar Futures

- **Substitute BPV for the abstract concept of change in value**

$$BPV \approx \Delta Value$$

- **May be used to find "Hedge Ratio" (HR) or # of futures needed to offset risk associated with spot instrument**

$$HR = \Delta \text{Value of Hedged Instrument} \div \Delta \text{ Value of Futures}$$

$$= BPV_{hedged} \div BPV_{futures}$$

$$= [FV \times (d/360) \times 0.01\%] \div \$25$$

- **EXAMPLE: Find # of CME Eurodollar futures needed to match with $25 million 180-day LIBOR investment**
  - **BPV of investment equals $1,250 [=$25,000,000 x (180/360) x 0.01%]**
  - **Sell 50 CME Eurodollar futures to hedge risk of rising rates and falling values**

$$HR = [\$25{,}000{,}000 \times (180/360) \times 0.01\%] \div \$25$$

$$= 50 \text{ contracts}$$

Hedging Swaps with CME Eurodollar Futures

Hedging cash flows of a swap …

Position	Risk	Hedge
Fixed Rate Payer ("Long the Swap")	Rates fall and prices rise	Buy CME Eurodollar futures
Floating Rate Payer ("Short the Swap")	Rates rise and prices fall	Sell CME Eurodollar futures

Hedging Swaps with CME Eurodollar Futures

- **EXAMPLE: Find BPV of 2-year IMM-dated swap with a $10 million principle amount as discussed above**
  - **Compare original swap value with NPP=$0 to swap value calculated assuming yields advances by 1 basis point (0.01%)**

Payment Date	Fixed Payments	Discount Factor (PV)	PV of Fixed Payments	Floating Payments	Discount Factor (PV)	PV of Floating Payments
12/21/05	$107,425.84	0.9899	$106,346.16	$101,266.67*	0.9899	$100,248.89
03/15/06	$107,425.84	0.9805	$105,328.69	$96,600.00	0.9805	$94,714.19
06/21/06	$107,425.84	0.9693	$104,126.83	$115,422.22	0.9693	$111,877.65
09/20/06	$107,425.84	0.9589	$103,009.78	$108,441.67	0.9589	$103,983.84
12/20/06	$107,425.84	0.9485	$101,897.06	$109,200.00	0.9485	$103,579.91
03/21/07	$107,425.84	0.9382	$100,788.80	$109,958.33	0.9382	$103,164.83
06/20/07	$107,425.84	0.9280	$99,690.11	$110,211.11	0.9280	$102,274.81
9/19/07	$107,425.84	0.9178	$98,598.46	$110,716.67	0.9178	$101,618.87
			$819,785.88			$821,462.99

  - **Difference in PV of floating and fixed payments changes by $1,677.12 [=$PV_{floating}$-$PV_{fixed}$=$821,462.99-$819,785.88]**

***** **First payment in December 2005 is fixed as of date on which the transaction was concluded in September. Thus, there is no change in floating payment and no risk associated with first set of cash flows.**

Hedging Swaps with CME Eurodollar Futures

- **THUS … the BPV of the swap = $1,677.12**
- **Seller of swap (floating rate payer) should hedge risk of rising rates by selling 67 CME Eurodollar futures**

$$HR = BPV_{hedged} \div BPV_{futures}$$
$$= \$1{,}677.12 \div \$25$$
$$= 67$$

- **BUT … sell which contract month? ANSWER … sell a strip or series of futures matched to each dated cash flow**
  - **Find BPV for the cash flows associated with 2-year swap**
  - **Match PV of payments ($PV_{fixed} = PV_{floating}$) on each date**
  - ***E.g.,* per original pricing, PV_{fixed} exceeds $PV_{floating}$ in March 2006 by $10,844 … if rates increase 0.01%, difference becomes $10,614 … resulting in profit for fixed rate payer ("long the swap") and loss for floating rate payer ("short the swap") of $229 … floating rate payer might have hedged by selling 9 March 2006 futures**

Hedging Swaps with CME Eurodollar Futures

Finding Hedge Ratio (HR) for each payment date …

	Original Scenario			Rates Rise 1 Basis Point				
Payment Dates	(1) PV of Fixed Payments	(2) PV of Floating Payments	(3) Float-Fixed (2)-(1)	(4) PV of Fixed Payments	(5) PV of Floating Payments	(6) Float-Fixed (5)-(4)	(7) Diff in Cash Flows (6)-(3)	(8) Hedge Ratio (7)÷$25
12/21/05	$106,348.88	$100,251.45	-$6,097.43	$106,346.16	$100,248.89	-$6,097.27	$0.16	0.0
03/15/06	$105,333.81	$94,490.01	-$10,843.81	$105,328.69	$94,714.19	-$10,614.50	$229.31	9.2
06/21/06	$104,134.70	$111,622.22	$7,487.52	$104,126.83	$111,877.65	$7,750.82	$263.30	10.5
09/20/06	$103,020.14	$103,751.89	$731.75	$103,009.78	$103,983.84	$974.07	$242.31	9.7
12/20/06	$101,909.86	$103,353.12	$1,443.26	$101,897.06	$103,579.91	$1,682.85	$239.59	9.6
03/21/07	$100,803.98	$102,943.17	$2,139.19	$100,788.80	$103,164.83	$2,376.03	$236.84	9.5
06/20/07	$99,707.62	$102,058.16	$2,350.54	$99,690.11	$102,274.81	$2,584.70	$234.16	9.4
9/19/07	$98,618.24	$101,407.21	$2,788.97	$98,598.46	$101,618.87	$3,020.41	$231.45	9.3
	$819,877.24	$819,877.24	$0	$819,785.88	$821,462.99	$1,677.12	$1,677.12	67.1

Hedging Swaps with CME Eurodollar Futures

- **THUS, appropriate hedge is to sell 67 futures …**

Sell	9	March 2006	CME Eurodollar futures
Sell	11	June 2006	CME Eurodollar futures
Sell	10	September 2006	CME Eurodollar futures
Sell	10	December 2006	CME Eurodollar futures
Sell	9	March 2007	CME Eurodollar futures
Sell	9	June 2007	CME Eurodollar futures
Sell	9	September 2007	CME Eurodollar futures

- **Hedge is "self liquidating" as futures contracts will settle in cash as each payment/expiration date passes by**