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Three-Month Euribor Futures: The Basics

Contents

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EURIBOR FUTURES CONTRACT TERMS

Exhibit 1 summarizes the terms of the Three-Month Euribor futures contract, known by its CME Globex ticker symbol as EB. The following passages scrutinize:

- Ttrading unit (the underlying reference from which the contract derives);
- Schedule of delivery months and last trading days;
- Contract price mechanism;
- Tick sizes (minimum price increments) for trading; and
- Notional contract size.

Exhibit 1 – CME Three-Month Euribor Futures Contract Specifications

(All times of day are Chicago Time unless otherwise noted.)

Trading Unit	Interest on a euro interbank deposit having approximately €1 mln principal value for a term of three months, for spot settlement on 3rd Wednesday of contract Delivery Month	
Delivery Months	Nearest 40 months in March Quarterly cycle plus nearest 4 months not in March Quarterly cycle	
Price Basis	IMM price points: 100 points minus 3-month euro interbank offered rate for spot settlement on 3rd Wednesday of Delivery Month (eg, a 6.33 percent rate equals 93.67 points). One interest rate basis point (0.01 price points) equals €25 per contract.	
Price Increments	*Nearest Delivery Month* ¼ of one interest rate bp (0.0025 price points) = €6.25 per contract. *All other Delivery Months* ½ of one interest rate bp (0.005 price points) = €12.50 per contract. "New" Nearest Delivery Month futures begin trading in 0.0025 price point increments at start of final Globex trading session for expiring "old" Nearest Delivery Month futures, ie, typically at 5pm Chicago time (midnight Central Europe time) on afternoon (evening) preceding termination of trading in expiring futures.	
Last Trading Day	Second Trans-European Automated Real-time Gross settlement Express Transfer (TARGET) System business day before 3rd Wednesday of Delivery Month	
Delivery Standard	Three-month Euribor® for spot (T+2) settlement on 3rd Wednesday of Delivery Month, rounded to nearest 1/10th of one basis point (equal to €2.50 per contract).	
Delivery Method	Cash settlement, by mark-to-market to Final Settlement Price. Final Settlement Price = Price Basis evaluated at Delivery Standard. Final settlement occurs on Last Trading Day.	
Trading Hours	CME Globex: 5pm to 4pm, Sun-Fri. Trading in expiring futures terminates at 11am Central Europe time (typically 4am Chicago time) on Last Trading Day.	
Position Accountability	10,000+ contracts	
Reportable Positions	850+ contracts	
Block Trade Thresholds	Nearest 20 March Quarterly Delivery Months and all Delivery Months not in March Quarterly cycle: 2,000+ contracts	Farthest 20 March Quarterly Delivery Months: 500+ contracts

Source: CME Group

Trading Unit

The underlying cash-market reference for any EB contract is *interest* on a *euro interbank deposit* having approximately €1 million principal value, with a term to maturity of *three months*, for *spot settlement* on the 3rd Wednesday of the contract Delivery Month. They look obvious, but the components of this definition repay close examination.

Euro Interbank Deposit
…is a euro deposit booked by one bank (or bank branch) with another, where both parties are domiciled within the European Monetary Union.

Standard Spot Settlement
…for a three-month euro interbank deposit is T+2. The settlement date (when borrower receives lender's monies) occurs two TARGET business days after the trade date (when borrower and lender agree to the deposit's amount and rate of interest). Three months later the interbank deposit matures.

> ***Example 1***
> A three-month interbank placement is undertaken on Monday, 18 February, for settlement on the third Wednesday of the month, 20 February. Borrower repays lender principal plus interest on 20 May. If 20 May happens not to be a TARGET business day, then the placement matures on the next following TARGET business day.

How Long is Three Months?
In regular years the interval from 20 February to 20 May spans 89 days. In leap years it covers 90 days, owing to February's extra 29th day. By contrast, the three months from 20 May to 20 August span 92 days.

Clearly, not all three-month intervals are created equal. Given the features of the TARGET system holiday calendar and the conventions that determine settlement and maturity dates for euro interbank placements, "three months" may run as short as 86 days or as long as 95 days. The day count matters, because it bears directly upon the interest amount borrower pays to lender.

Interest
…on a euro interbank deposit is always calculated on an actual/360 basis. The rate per annum to which lender and borrower agree is assumed to accrue so that the actual number of days between settlement date and maturity date is applied to a 360-day year.

> ***Example 2***
> On Monday, 18 February, lender agrees to extend €1 million to borrower at a rate of 5 percent per year for three months, for standard spot settlement. Two TARGET business days later, on Wednesday, 20 February, lender remits €1 million to borrower. Assuming February has its usual 28 days (as in 1991, or 2002, or 2013), borrower repays lender €1 million principal plus interest 89 days later, on Monday, 20 May. The interest amount is:
>
> €12,361.11 = (€1 million) x (5 percent per year) x (89 days / 360 days per year)
>
> ***Example 3***
> If the loan in Example 2 is undertaken in a leap year (eg, 1980 or 2008), then borrower repays lender principal plus interest 90 days later, on Tuesday, 20 May. The interest amount is:
>
> €12,500.00 = (€1 million) x (5 percent per year) x (90 days / 360 days per year)

Delivery Month and Last Trading Day

Quarterlies

At any given time the exchange lists for trading 40 Quarterly EB futures delivery months -- one for every March, June, September, and December reaching a decade forward. Each EB contract ceases trading and expires on the second TARGET business day (typically the Monday) before the third Wednesday of its delivery month. When the nearby Quarterly expires, a new fortieth Quarterly is listed for trading on the next following exchange business day (typically the Tuesday before the third Wednesday of the month).

Example 4

EB futures for delivery in March 2013 are scheduled to cease trading and expire on Monday, 18 March 2013. On the following exchange business day, Tuesday, 19 March 2013, trading is scheduled to commence in newly-listed EB futures for delivery ten years hence, in March 2023.

Monthly Serials

Monthly Serial EB futures are identical to Quarterlies except for their delivery months, which are any months other than March, June, September, or December. At any given time the Exchange lists four Monthly Serials.

Example 5

October 2013 Monthly Serial EB futures are scheduled to expire on Monday, 14 October 2013, the second TARGET business day before the third Wednesday of the month. On the next exchange business day, Tuesday, 15 October 2013, a new Monthly Serial, for delivery in April 2014, is scheduled to be listed for trading alongside the extant three Monthly Serials, for delivery in November 2013, and January and February 2014.

Nearby

…is simply the EB futures contract that expires next. It can be either a Quarterly or a Monthly Serial.

Color Coding

For ease of identification the 40 Quarterly delivery months are grouped into ten foursomes. Each foursome is identified by its own unique color code. In order of proximity to expiration, these are White, Red, Green, Blue, Gold, Purple, Orange, Pink, Silver, and Copper.

Exhibit 2 illustrates for a hypothetical day in early autumn 2013. The White year comprises the nearest four Quarterly delivery months – in this example, December 2013, and March, June, and September 2014. The Red delivery year comprises the fifth through eighth nearest Quarterly delivery months – here, December 2014, and March, June, and September 2015 -- and so on.

Exhibit 2
Color-Coding of EB Futures Delivery Months – Example: Early Autumn 2013

Delivery Month	Delivery Year	Color Code
OCT	2013	Monthly Serial
NOV	2013	
DEC	2013	White
JAN	2014	Monthly Serial
FEB	2014	
MAR	2014	White
JUN	2014	
SEP	2014	
DEC	2014	Red
MAR	2015	
JUN	2015	
SEP	2015	
DEC	2015	Green
MAR	2016	
JUN	2016	
SEP	2016	
DEC	2016	Blue
MAR	2017	
JUN	2017	
SEP	2017	
DEC	2017	Gold
MAR	2018	
JUN	2018	
SEP	2018	
DEC	2018	Purple
MAR	2019	
JUN	2019	
SEP	2019	
DEC	2019	Orange
MAR	2020	
JUN	2020	
SEP	2020	
DEC	2020	Pink
MAR	2021	
JUN	2021	
SEP	2021	
DEC	2021	Silver
MAR	2022	
JUN	2022	
SEP	2022	
DEC	2022	Copper
MAR	2023	
JUN	2023	
SEP	2023	

Price = 100 Minus Rate

EB futures prices are quoted in "100 minus rate" terms.[1] Price is expressed on the basis of 100 points, with each point representing one percent (ie, 100 basis points) per annum of contract interest rate exposure.

At Futures Expiration – Final Settlement Price

"Delivery" on expiring futures takes place not by physical delivery and acceptance of a three-month euro interbank deposit, but rather by cash settlement. The contract is fulfilled by a mark-to-market to its final settlement price. The final settlement price is determined as 100 minus three-month Euribor® on the second TARGET bank business day preceding the third Wednesday of the contract delivery month.

Euribor® is calculated and published on each TARGET system business day by Thomson Reuters, under the sponsorship of Euribor-EBF. Three-month Euribor® is published to three decimal places of accuracy, ie, to the nearest 1/10th of one basis point per annum.[2]

Example 6

A published three-month Euribor® value of 3.142 percent would result in a futures final settlement price of 96.858, equal to 100 minus 3.142.

Before Futures Expiration – Contract Price and Contract Interest Rate

The contract interest rate (equal to 100 minus contract price) is approximately the market consensus expectation of the three-month euro interbank offered rate for settlement on the third Wednesday of the contract delivery month.[3]

Example 7

If a EB futures contract is priced at 93.670 five months prior to expiration, the implication is that the market consensus expectation calls for three-month euro deposits to be offered in the Eurozone interbank market at a rate of approximately 6.330 percent per annum for spot settlement five months hence.

Two features of this pricing scheme are noteworthy. One is that it ensures a loose but intuitively appealing imitation of the inverse relationship between a bond's price and its interest rate. If the contract's reference interest rate rises, the contract price falls, and vice versa. A change of one interest rate basis point is always equal in magnitude, and opposite in sign, to a futures price change of 0.01 price points.

The second feature is that, practically speaking, the futures price is bounded by a minimum of zero and a maximum of 100 points. As a purely theoretical matter these bounds are not strict. Futures price might exceed 100, but only if market participants broadly expect the corresponding three-month euro interbank deposit rate to be set at negative levels. Similarly, futures price might drop below zero, but only if the contract's reference three-month interest rate were generally expected to exceed 100 percent per year.

[1] When introduced in 1981, Three-Month Eurodollar futures were listed for trading under the auspices of what was then the International Money Market (IMM) division of Chicago Mercantile Exchange. The "100 minus rate" contract pricing engine – a pioneering feature of the Eurodollar futures contract design, now in wide use at futures exchanges around globe -- came thus to be known as the "IMM Index."

[2] For more detail, see **Appendix: A Concise Guide to Euribor®** on page 23.

[3] To see why the two are "approximately" equal rather than exactly equal, see **Futures Rates, Forward Rates, and Convexity Bias** on page 21.

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Contract Size and Price Increments

One Basis Point = €25

The notional scale of the EB futures contract is defined in terms of the price value of one interest rate basis point per annum, or PV01. One basis point (0.01 contract price points, or one "tick") is always worth €25. Crucially, this applies regardless of the length of time until the contract expires.[4]

Minimum Price Increment = ½ Tick or ¼ Tick

With one exception, the minimum price movement for trading EB futures is one half of one interest rate basis point (0.005 contract price points or ½ tick), equal to €12.50 per contract.

The exception is the nearby contract[5] for which the minimum price movement is one quarter of one interest rate basis point (0.0025 contract price points or ¼ tick), equal to €6.25 per contract. On the eve of the nearby contract's last day of trading, the next expiring contract, whether Quarterly or Monthly Serial, begins trading in ¼ tick minimum price increments.

> ***Example 8***
> May 2015 Monthly Serial EB futures become the nearest expiring contract on Monday, 13 April 2015, the last day of trading in the April 2015 Monthly Serial. The minimum price increment for the May 2015 contract graduates from ½ tick to ¼ tick as of 5pm Chicago time on Sunday, 12 April 2015, when the CME Globex trading session commences for the Monday, 13 April, trade date. The May 2015 contract continues to trade in ¼ tick price increments until it too ceases trading and expires on Monday, 18 May 2015, at which time nearby status passes to the June 2015 Quarterly.

Notional Contract Size = €1 Million … More or Less

A popular rule of thumb says the value of one basis point of EB futures contract interest is €25, because the size of the notional interbank deposit that serves as the contract's underlying reference is €1 million. The following equivalence formalizes the point:

€25 per bp **= (€1 million) x (0.01 percent per year) x (*90 days* / 360 days per year)**

If taken too literally, however, this rule of thumb may confuse rather than enlighten. That's because it describes the structure of the EB futures contract backwards.

In fact, the contract's notional bank placement turns out to be *approximately* €1 million because the contract terms explicitly fix the PV01 at €25. To see why this matters, recall that three-month intervals vary widely in duration.[6] With this in mind we can rearrange the equivalence above to show how the notional size of the contract reference bank deposit depends on the day count for the bank deposit's term, subject to the requirement that the PV01 must be €25:

€1 million **= (€25 per bp) / { (0.01 percent per year) x (*90 days* / 360 days per year) }**

If the three-month interval beginning on the third Wednesday of a contract's delivery month spans 90 days, then the size of the contract's notional interbank placement will indeed be €1 million.

But as Column (2) of Exhibit 3 demonstrates, if the day count is 92 days instead of 90, then the notional bank placement's principal value must be around €978,261 for the PV01 to remain €25:

€978,260.87 **= (€25 per bp) / { (0.01 percent per year) x (*92 days* / 360 days per year) }**

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[4] To see why this is "crucial," see **Futures Rates, Forward Rates, and Convexity Bias** on page 21.

[5] Recall that "nearby" applies to both Quarterly and Monthly Serial delivery months. See **Nearby** on page 4.

[6] See **How Long is Three Months?** on page 3.

Similarly, if the day count were 89 days rather than 90, the interbank placement's principal value would need to be around €1,011,236 to keep the PV01 pinned at €25.

Instead of assuming that the PV01 is fixed at €25, one could maintain the assumption that the size of the interbank placement is fixed. If so, then as the day count for the placement's three-month interval lengthens, the PV01 rises, and the number of EB futures required to hedge the placement's interest rate exposure rises correspondingly. Columns (3) and (4) illustrate this for a bank deposit size fixed at €1 billion.

In sum, to say an EB futures contract represents an interbank deposit with principal value of roughly €1 million remains a useful heuristic. But the more basic point is that contract notional size is determined not by the nominal size of the underlying reference bank placement, but rather by the fact that *one basis point of EB contract interest is defined to be worth €25, at all times, in all places*.

Exhibit 3 – EB Futures Notional Interbank Deposit Size, Interest Rate Sensitivity, and Day Count

(1) Length of Reference Bank Deposit's 3-Month Interval (Days)	(2) Deposit Size Required for PV01 to Equal €25 (Euros)	(3) PV01 for Deposit = €1 Million (Euros per Basis Point)	(4) Number of EB Futures Required to Hedge Deposit = €1 Billion (1000 x (3) / €25)
86	1,046,511.63	23.89	956
87	1,034,482.76	24.17	967
88	1,022,727.27	24.44	978
89	1,011,235.96	24.72	989
90	1,000,000.00	25.00	1,000
91	989,010.99	25.28	1,011
92	978,260.87	25.56	1,022
93	967,741.94	25.83	1,033
94	957,446.81	26.11	1,044
95	947,368.42	26.39	1,056

Source: CME Group

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TRADING EURIBOR FUTURES

How EB futures trade is as important as the contract mechanism. The following sections spell out some of the more important rule of the road:

- Workings of EB Pack and Bundle trades
- Other EB combinations available to market participants in standardized form;
- How trade prices for such combinations get transformed into prices of component EB contracts
- Algorithms by which CME Globex matches buyers and sellers to effect transactions
- Process by which the Exchange establishes daily settlement prices for EB futures

Bundles and Packs

Many hedging and trading strategies call for the purchase or sale of EB futures in "strips," or sequences of consecutive contract delivery months. Executing each of a strip's component contracts, one by one, can be time-consuming and cumbersome. Worse, it may slow up position entry or exit, saddling the user with significant slippage in fast-moving markets.

EB Bundles and Packs provide a handy alternative. In a Bundle or Pack transaction, one buys or sells a strip of futures in a single trade, saving time and effort, and eliminating much inconvenience.

Packs

A Pack is the simultaneous sale or purchase of one each of a series of four EB futures with consecutive Quarterly delivery months. A Pack may be structured so that the nearest of its member contracts is any of the first 37 Quarterly delivery months. The most popular Packs tend to be those corresponding to the ten color-coded delivery years, White through Copper, shown in Exhibit 2.[7] For instance, a Green Pack transaction on a day in early autumn 2013 would entail simultaneous purchase or sale of one each of the four contracts for the 9th through 12th nearest delivery months -- in this case, one each of the December 2015 and March, June, and September 2016 futures.

Bundles

A Bundle is the simultaneous sale or purchase of one each of a series of eight or more EB futures with consecutive Quarterly delivery months. Bundles are listed in yearly tenors, from two to 10 years. (There are no one-year Bundles, because Packs effectively play this role.) As with Packs, the nearest member contract in a Bundle may be any Quarterly delivery month, as long as there is a sufficient number of ensuing Quarterly delivery months to accommodate the Bundle's tenor. The most popular Bundles tend to be those for which the nearest contract in the Bundle sequence is the nearby Quarterly. See Exhibit 4.

Exhibit 4 – EB Futures Bundles

Bundle Tenor (Years)	Bundle = 1 Each of the Following Quarterly Contracts:	DV01 (Dollars)	DV per 1/4 Tick (Dollars)
2	Nearest 8	200	50
3	Nearest 12	300	75
4	Nearest 16	400	100
5	Nearest 20	500	125
6	Nearest 24	600	150
7	Nearest 28	700	175
8	Nearest 32	800	200
9	Nearest 36	900	225
10	Nearest 40	1,000	250
5-Year Forward	Back 20 (Purple to Copper Years)	500	125

Source: CME Group

[7] See **Color Coding** on page 4.

Bundle and Pack Prices

The price of any Bundle or Pack is quoted as the average change among its member EB contracts from their respective previous daily settlement prices. Prices are quoted in increments of ¼ tick.

For any Pack, the PV01 is €100, and the dollar value of a ¼ basis point (ie, ¼ tick) interest rate change is always €25. The third column of Exhibit 4 summarizes the interest rate sensitivity of highly traded Bundles in terms of their PV01s. These range from €200 for the Two-Year Bundle to €1,000 for the 10-Year Bundle. The fourth column shows the same in terms of the dollar value of a ¼ basis point (¼ tick) rate move.

How Bundle and Pack Prices Become EB Contract Prices

Once a Bundle or Pack is transacted, the price change at which it trades is assigned to each of its member contracts, in increments of 1 tick.[8] If the Bundle or Pack trade price is an integer number of ticks (eg, -7 ticks on the day), then each constituent contract gets booked at a trade price equal to its previous daily settlement price adjusted by the Bundle or Pack price (eg, previous daily settlement price minus 7 ticks).

If the Bundle or Pack trade price involves a fractional portion (¼ or ½ or ¾) of a tick, then the exchange uses the following method to assign prices to the member contracts:

(1) Initially, each member contract is assigned a price change equal to the integer (non-fractional) portion of the Bundle or Pack price.

(2) The individual contract price changes are then adjusted, one by one, until their average value equals the Bundle or Pack price. If the Bundle or Pack price is positive, the adjustment pushes the individual contract price change up to the next higher tick. If the Bundle or Pack price is negative, the adjustment pushes the individual contract price change down to the next lower tick.

(3) Importantly, the adjustment process described in (2) starts with the most distant delivery month among the contracts in the Bundle or Pack, then works forward until the average of all contract price changes matches the Bundle or Pack price.

With the prices of its constituent contracts thus determined, the Bundle or Pack is promptly unbundled (or unpacked, as the case may be). From then on, each member contract is marked to market and otherwise treated as if it were a stand-alone EB futures position.

Example 9

The Two-Year Bundle trades at +2.25 ticks. To accommodate the ¼ tick portion of the Bundle price, the Bundle's two most deferred contracts get booked at trade prices equal to their previous daily settlements plus 3 ticks, while the six nearest contracts get booked at trade prices equal to their previous daily settlements plus 2 ticks. The average price increment among the Bundle's eight member contracts is as it should be:

+2.25 ticks =
{ (6 nearest contracts x +2 ticks) + (2 most deferred contracts x +3 ticks) } / 8 contracts

Suppose the Ten-Year Bundle trades at -5.75 ticks. Among its 40 member contracts, the 30 most distant delivery months get booked at a net price change of -6 ticks versus their previous daily settlement prices, while the nearest 10 delivery months are assigned a net price change of -5 ticks.

-5.75 ticks =
{ (10 nearest contracts x -5 ticks) + (30 most deferred contracts x -6 ticks) } / 40 contracts

[8] To learn how CME Globex matches buyer and seller to make the Bundle or Pack transaction in the first place, see **CME Globex Trade Matching Algorithms for EB Futures** on page 18.

Assume the Purple Pack trades at +0.5 ticks. The third and fourth delivery months within the Pack get booked at a net price change of +1 tick versus their respective previous daily settlement prices. The first and second delivery months get booked at prices unchanged from their previous daily settlements --

+0.5 ticks =
{ (2 nearest contracts @ unchanged) + (2 most deferred contracts x +1 tick) } / 4 contracts

Calendars, Flies, Condors, and Other Combinations

In addition to Packs and Bundles, eight other popular combination strategies are standardized on CME Globex, permitting market participants to transact them directly in spread form, instead of having to leg into or out of them. These include calendar spreads, butterflies, double butterflies, condors, month-Pack spreads, Pack spreads, Pack butterflies, and Bundle spreads.

For the first four – calendar spreads, butterflies, double butterflies, and condors -- the building blocks are individual EB contracts.

Calendar Spread
…consists of two EB contracts with different delivery months. When traded on CME Globex, the ratio for purchase of a calendar spread is always +1:-1. Thus, buying 1 calendar spread means:

(a) buying 1 nearer delivery month (Leg1) and
(b) selling 1 farther delivery month (Leg2).

The calendar spread price is quoted as (Leg1 price) minus (Leg2 price). For any calendar spread in which at least one leg is either a Monthly Serial and/or the nearby Quarterly delivery month, the minimum price movement for trading is one quarter of one spread basis point (0.0025 contract price points or ¼ tick), equal to €6.25 per spread.

Example 10
Consider a Jan-Mar calendar spread, and assume the January Monthly Serial and March Quarterly contracts are trading, respectively, at 99.6625 and 99.59.[9] The Jan-Mar spread would be fairly valued at 7.25 ticks, equal to 99.6625 minus 99.59.

For any other calendar spread the minimum price movement is one half of one calendar spread basis point (0.005 price points or ½ tick), equal to €12.50 per spread.

Example 11
Suppose the Red June and Blue June contracts are trading at 99.44 and 97.61, respectively. The Red-Blue June two-year calendar spread would be fairly valued at 183.0 ticks, equal to 99.44 minus 97.61.

[9] For a precise definition of what it means for a EB contract to "be trading" at a given price, see **C-Last Price** on page 13.

Butterfly

… comprises three Quarterly EB contracts with equally distributed delivery months. CME Globex routinely enables trading in butterflies in three standardized configurations: three-month (eg, Jun13-Sep13-Dec13), six-month (eg, Jun13-Dec13-Jun14), nine-month (eg, Jun13-Mar14-Dec14), and one-year (eg, Jun13-Jun14-Jun15). In all instances, the ratio for purchase of a butterfly is +1:-2:+1. So buying 1 butterfly means:

(a) buying 1 of the nearest delivery month (Leg1),
(b) selling 2 of the second nearest delivery month (Leg2), and
(c) buying 1 of the farthest delivery month (Leg3).

The butterfly spread price is quoted as (Leg1 price) minus (2 x Leg2 price) plus (Leg3 price). Minimum price movement is always one half of one spread basis point (0.005 price points or ½ tick), equal to €12.50 per spread.

Double Butterfly

… combines four Quarterly EB contracts with equally distributed delivery months. It's useful to imagine a double butterfly as a calendar spread between two conventional butterflies, in which the second and third legs of the nearer butterfly also serve duty as the first and second legs, respectively, of the more distant butterfly. Accordingly, the double butterfly spread ratio is always +1:-3:+3:-1. That is, buying 1 double butterfly entails:

(a) buying 1 of the nearest delivery month (Leg1),
(b) selling 3 of the second nearest delivery month (Leg2),
(c) buying 3 of the third nearest delivery month (Leg3), and
(d) selling 1 of the farthest delivery month (Leg4).

CME Globex customarily permits trading in three variants: three-month (eg, Jun13-Sep13-Dec13-Mar14), six-month (eg, Jun13-Dec13-Jun14-Dec14), and one-year (eg, Jun13-Jun14-Jun15-Jun16). Price is always quoted as (Leg 1 price) minus (3 x Leg 2 price) plus (3 x Leg 3 price) minus (Leg 4 price). Minimum price movement is one half of one spread basis point (0.005 price points or ½ tick), equal to €12.50 per spread.

Condor

… is a combination of four Quarterly EB contracts with equally distributed delivery months. As with double butterflies, three species of condor are routinely available for trading on CME Globex, distinguished from one another by breadth of wing span: three-month (eg, Jun13-Sep13-Dec13-Mar14), six-month (eg, Jun13-Dec13-Jun14-Dec14), and one-year (eg, Jun13-Jun14-Jun15-Jun16). The spread ratio is always +1:-1:-1:+1. So buying a condor means:

(a) buying 1 of the nearest delivery month (Leg1),
(b) selling 1 of the second nearest delivery month (Leg2),
(c) selling 1 of the third nearest delivery month (Leg3), and
(d) buying 1 of the farthest delivery month (Leg4).

Price is quoted as (Leg1 price) minus (Leg2 price) minus (Leg3 price) plus (Leg4 price). Minimum price movement is one half of one spread basis point (0.005 price points or ½ tick), equal to €12.50 per spread.

Example 12

Suppose White March, White June, and White September contracts are trading at 99.585, 99.44, and 99.29, respectively. The corresponding three-month butterfly would be fairly valued at -0.5 ticks, equal to 99.585 minus (2 x 99.44) plus 99.29. If White June, Red June, Green June, and Blue June contracts are trading, respectively, at 99.45, 98.78, 97.80, and 96.795, then the corresponding one-year double butterfly would be fairly valued at -28.5 ticks, equal to 99.45 minus (3 x 98.78) plus (3 x 97.80) minus 96.795.

The remaining four standardized combinations – month-Pack spreads, Pack spreads, Pack butterflies, and Bundle spreads – employ EB Packs and Bundles as their elementary building blocks.

Month-Pack Spread

…consists of a position in a Pack combined with a countervailing position in a single EB futures contract with a Quarterly delivery month. The four EB contracts in the Pack leg are always the next four Quarterly delivery months immediately following the delivery month for the contract on the singleton leg. The spread ratio is always (+4 singletons):(-1 pack). In other words, buying a month-Pack spread entails:

(a) buying 4 of the (nearer) single EB delivery month and
(b) selling 1 (more distant) Pack.

Pack Spread

…is similar to the futures calendar spread described above, except built with Packs instead of individual futures contracts. Each of the spread's two Packs corresponds to one of the color-coded delivery years exemplified in Exhibit 2. Thus, the futures delivery months represented in the Pack on one leg are always removed from the futures delivery months in the Pack on the other leg by an integer multiple of one year, ranging from one (eg, White-Red, Silver-Copper) to nine (uniquely, White-Copper). The spread ratio is always +1:-1. Buying 1 Pack spread means:

(a) buying 1 Pack of EB contracts with nearer delivery months (Leg 1) and
(b) selling 1 Pack of EB contracts with more distant delivery months (Leg 2).

Pack Butterfly

…is simply a butterfly spread where each of the legs is a Pack. As with the Pack Spread, each of the Packs in the butterfly must correspond to one of the ten color-coded EB futures delivery years. CME Globex permits trading in two species of Pack butterfly: one-year (eg, Green-Blue-Gold) and two-year (eg, Green-Gold-Orange). As with the futures butterfly, the spread ratio for purchase of a Pack butterfly is always +1:-2:+1. So buying 1 Pack butterfly means:

(a) buying 1 Pack of EB contracts with four nearest delivery months (Leg 1),
(b) selling 2 Packs of EB contracts with next four nearest delivery months (Leg 2),
(c) buying 1 Pack of EB contracts with the most distant four delivery months (Leg 3).

Bundle Spread

…is a calendar spread between two Bundles. The Bundle on one leg must comprise *at least two* EB futures delivery months that are not represented in the Bundle on the other leg. Moreover, each leg must have the same number of constituent EB contracts as the other leg. For instance, a Two-Year Bundle can be paired only with another Two-Year Bundle to make a Bundle spread. The Bundle spread ratio is always +1:-1. Buying 1 Bundle spread means:

(a) buying 1 Bundle of EB contracts for nearer delivery (Leg 1) and
(b) selling 1 Bundle of EB contracts for more distant delivery (Leg 2).

Prices of month-Pack spreads, Pack spreads, Pack butterflies, and Bundle spreads are quoted in the same terms as for the component Packs and Bundles. In each case, the spread price is quoted as the net change on the day among the legs of the spread,[10] and the minimum price movement is one quarter of one spread basis point (0.0025 contract price points or ¼ tick).

Example 13
Suppose Red, Green, and Blue Packs are trading (in their characteristic net-change-on-the-day terms) at -10 ticks, -18 ticks, and -25.25 ticks, respectively.[11] The Red-Blue 2-year Pack spread would be fairly valued at a net change of +15.25 ticks, equal to (-10 ticks) minus (-25.25 ticks), and the Red-Green-Blue one-year Pack butterfly would be fairly priced at a net change of +0.75 ticks, equal to (-10 ticks) minus (2 x -18 ticks) plus (-25.25 ticks).

How Combination Prices Become EB Contract Prices

Like Packs and Bundles, the other eight combination strategies described above are standardized so as to facilitate position entry or exit through one transaction rather than many. Another important similarity is that, from the standpoint of the exchange, they are ephemeral. Like a Pack or a Bundle, a calendar spread or butterfly or condor is not marked-to-market as such. It loses its identity at the moment CME Globex assigns prices to its constituent EB contracts. From then on, each of the spread's member EB contracts is marked-to-market and otherwise treated as if it were a distinct EB futures position.

The chief difference between Packs and Bundles versus the other combination strategies is how CME Globex translates their trade prices into prices for booking the member EB contracts. As described earlier,[12] the price of a Pack or Bundle is apportioned to its constituent contracts on the basis of (a) each contract's net price change versus its latest daily settlement price and (b) the length of term to expiry for each contract relative to the other contracts in the Pack or Bundle.

By contrast, the price of a calendar spread, butterfly, double butterfly, condor, or month-Pack spread is distributed to its component EB contracts essentially on the basis of current market conditions in those contracts. Before we explain the process, an item of terminology requires introduction.

C-Last Price
The CME Last (or C-Last) price for a EB contract for a given delivery month is simply the contract's latest trade price, or actionable price indication, or settlement price. Specifically, the C-Last price is the most recent of:

(a) latest CME Globex transaction price, or
(b) CME Globex bid price that betters the bid side of the market, or
(c) CME Globex asking price that betters the ask side of the market, or
(d) latest daily settlement price.

In this context, a bid that betters the market is understood to be a bid to buy at a higher price than the incumbent C-Last price. Similarly, a better ask price is an offer to sell at a price below the preceding C-Last price.

[10] For any month-Pack spread, the price of the EB futures contract on the spread's singleton leg is expressed not in the usual 100-minus-rate futures price format, but rather in terms of the net-change-on-the-day convention that applies to Packs.

[11] For a precise definition of what it means for a EB Pack or Bundle to "be trading" at a given price, see the definition of **Pack/Bundle C-Last Price** on page 16.

[12] See **How Bundle and Pack Prices Become EB Contract Prices** on page 9.

Calendar Spread = (+1 Leg1):(-1 Leg2)

To assign prices to a calendar spread's legs, CME Globex first checks which one has traded more recently during the current CME Globex trading session, and then assigns the fresh trade price to that leg. This is then combined with the transaction price of the calendar spread to derive the price of the other leg:

If Leg1 has traded more recently than Leg2, then
Leg1 is assigned its latest trade price and
Leg2 price = (Leg 1 price) minus (calendar spread price).

If Leg2 has traded more recently than Leg1, then
Leg2 is assigned its latest trade price and
Leg1 price = (Leg 2 price) plus (calendar spread price).

If the latest trades in both legs occurred simultaneously, then Leg1 takes precedence:

Leg1 is assigned its latest trade price and
Leg2 price = (Leg 1 price) minus (calendar spread price).

Finally, if there have been no trades in either of the Leg1 or Leg2 contracts during the current CME Globex trading session, then the calendar spread's legs are assigned on the basis of Leg1's latest daily settlement price:

Leg1 price = Leg1's latest daily settlement price, and
Leg2 price = (Leg1 price) minus (calendar spread price).

Example 14

Suppose the two-year calendar spread between the White June and Green June EB contracts trades at 165.5 ticks. Suppose that, of the two legs, the latest trade has occurred in Green June at a price of 97.80. For the buyer, CME Globex confirms the transaction as the sale of the Green June contract at its latest trade price of 97.80 and the purchase of the White June contract at an imputed price of 99.455, equal to Green June price plus calendar spread price, 97.80 plus 1.655. Conversely, the seller receives confirmation of a sale of White June at 99.455 and a purchase of Green June at 97.80.

Suppose instead that the latest transaction in Green June, at 97.80, coincides with a trade in White June at 99.43. The nearer White June contract takes pride of place. The buyer of the calendar spread receives confirmation of purchase of White June at its latest trade price, 99.43, and sale of Green June at a calculated price of 97.775, equal to White June price minus calendar spread price, or 99.43 minus 1.655, and conversely for the seller.

Butterfly = (+1 Leg1):(-2 Leg2):(+1 Leg3)

To assign prices to the legs of a butterfly, CME Globex books Leg1 and Leg2 at their respective C-Last prices, then derives Leg3's price as:

Leg3 price = (butterfly price) minus (Leg1 price) plus (2 x Leg2 price)

Double Butterfly = (+1 Leg1):(-3 Leg2):(+3 Leg3):(-1 Leg4)

To map a double butterfly price into its component contract prices, CME Globex sets Leg1, Leg2, and Leg3 at their respective C-Last prices, then computes Leg4's price as:

Leg4 price = (Leg1 price) minus (3 x Leg2 price) plus (3 x Leg3 price)
minus (double butterfly price)

Condor = (+1 Leg1):(-1 Leg2):(-1 Leg3):(+1 Leg4)

Likewise, to bust a condor price into its component contract prices, CME Globex books Leg1, Leg2, and Leg3 at their respective C-Last prices, and sets Leg4's price as:

Leg4 price = (condor price) minus (Leg1 price) plus (Leg2 price) plus (Leg3 price)

Example 15

The White Mar-Jun-Sep three-month butterfly trades at -1 tick. Assume C-Last prices for the White March and White June contracts are 99.585 and 99.44, respectively. CME Globex confirms to the buyer the purchase of one White March contract at 99.585, the sale of two White June contracts at 99.44, and the purchase of one White September contract at an imputed price of 99.285, equal to -0.01 minus 99.585 plus (2 x 99.44), and conversely to the seller.

The one-year double butterfly comprising White, Red, Blue, and Green June contracts trades at -27 ticks. Assume C-Last prices for White, Red, and Green June contracts are, respectively, 99.45, 98.78, and 97.80. CME Globex confirms to the buyer the purchase of one White June contract at 99.45, the sale of three Red June contracts at 98.78, the purchase of three Green June contracts at 97.80, and the sale of one Blue June contract at an imputed price of 96.78, equal to (Leg1 price) minus (3 x Leg2 price) plus (3 x Leg3 price) minus (double butterfly price), or 99.45 minus (3 x 98.78) plus (3 x 97.80) minus (-0.27).

Month-Pack Spread = +4 Leg1 EB:-1 Leg2 Pack

In distributing a month-Pack spread price to its components, CME Globex always accords precedence to the singleton EB contract on Leg1. With this in mind, it is convenient to imagine the price attribution process working in four steps:

(a) Leg1 EB contract is set to its C-Last price.
(b) Leg1 EB price is re-expressed in Pack-equivalent terms, as
(contract C-Last price) minus (contract previous daily settlement price)
(c) Leg2 Pack price is then derived as
(Leg1 Pack-equivalent price) minus (month-Pack spread price).
(d) Leg2 Pack price, as determined in Step (c), is then translated into price levels for each of the Pack's four member contracts, as described earlier.[13]

CME Globex confirms to the buyer the purchase of four Leg1 EB futures contracts at the price established in Step (a) and the sale of one each of the Pack's four constituent contracts as determined in Step (d). The seller of the spread receives the obverse confirmation.

[13] See **How Bundle and Pack Prices Become EB Contract Prices** on page 11.

Example 16

Consider the purchase of a month-Pack spread comprising purchase of four Red December EB contracts and sale of one Green Pack. The spread trades at +4.5 ticks. CME Globex apportions this spread price to the component contracts as follows:

(a') The Red December contract on Leg1 gets its C-Last price. Assume this is 99.11.
(b') The Red December contract price is re-expressed in Pack-equivalent terms. Assuming the contract's previous daily settlement price is 99.165, its Pack-equivalent price is -5.5 ticks, equal to 99.11 minus 99.165.
(c') The price of the Green Pack on Leg2 is derived as -10 ticks, equal to Leg1's Pack-equivalent price minus the month-Pack spread price, or (-5.5 ticks) minus (+4.5 ticks).
(d') Each of the Pack's four member contracts (Green March, June, September, and December) gets booked at its respective previous daily settlement price minus 10 ticks.

Understanding the futures contract price assignment process for the remaining three combinations -- Pack spreads, Pack butterflies, and Bundle spreads – calls for a modified definition of C-Last Price:

Pack/Bundle C-Last Price

Unlike the C-Last Price for a futures contract, the Pack/Bundle C-Last Price makes no reference to a previous daily settlement price.[14] Within any CME Globex trading session, the C-Last Price for a given Pack or Bundle is the most recent of:

(a) latest CME Globex transaction price, or
(b) CME Globex bid price that betters the bid side of the market, or
(c) CME Globex asking price that betters the ask side of the market.

If there is no C-Last Price for a given Pack or Bundle during the current CME Globex trading session, CME Globex calculates a synthetic price for the Pack or Bundle using futures C-Last Prices. For each EB contract in the Pack or Bundle, it obtains the differential between the contract's C-Last Price and the contract's previous daily settlement price. It then computes the arithmetic average of these differentials. The average value gets rounded to the nearest ¼ tick, with tie values rounded towards zero. For instance, an average of -2.125 ticks gets rounded up to -2 ticks, whereas an average of +5.625 ticks gets rounded down to +5.5 ticks.

One set of ground rules applies to contract price assignments for Pack spreads, Pack butterflies, and Bundle spreads. The nearby legs of the combination always take precedence, in the sense that they are always set to their respective Pack/Bundle C-Last Prices. The most deferred leg of the combination is always derived on the basis of the price(s) assigned to the other leg(s) and the combination trade price. Finally, with prices thus established for all Packs or Bundles involved in the combination, each Pack or Bundle price is then distributed to its respective member EB contracts, as described earlier.[15]

Pack Spread = (+1 Leg1 Pack):(-1 Leg2 Pack)

Leg1 Pack gets assigned its Pack C-Last Price, as defined above. Leg2 Pack price is then derived as the difference between Leg1 Pack price and the Pack spread price –

Leg1 Pack price = Leg1 Pack C-Last Price, and
Leg2 Pack price = (Leg1 Pack price) minus (Pack spread price).

[14] Technically, daily settlement prices are made only for futures contracts, not for Packs, Bundles, or any other combinations or spreads.

[15] As before, see **How Bundle and Pack Prices Become EB Contract Prices** on page 9.

Pack Butterfly = (+1 Leg1 Pack):(-2 Leg2 Packs):(+1 Leg3 Pack)

The Packs on Leg1 and Leg2 are given their respective Pack C-Last Prices. CME Globex then uses these and the Pack butterfly price to impute the price of the Leg3 Pack –

Leg1 Pack price = Leg1 Pack C-Last Price
Leg2 Pack price = Leg2 Pack C-Last Price
Leg3 Pack price = (Pack butterfly price) minus (Leg1 Pack price)
plus (2 x Leg2 Pack price)

Bundle Spread = (+1 Leg1 Bundle):(-1 Leg2 Bundle)

Leg1 Bundle is set to its Bundle C-Last Price, after which the Leg2 Bundle price is calculated as the difference between the Leg1 Bundle price and the Bundle spread price –

Leg1 Bundle price = Leg1 Bundle C-Last Price, and
Leg2 Bundle price = (Leg1 Bundle price) minus (Bundle spread price).

Example 17

The Red-Green one-year Pack spread trades at +8 ticks. Assume the Red Pack C-Last price is -10 ticks. Because it is the nearer of the two Packs, it gets booked at this price. The imputed price at which the Green Pack gets booked is -18 ticks, equal to the Leg1 price minus the spread price, or (-10 ticks) minus (+8 ticks). The buyer of the Pack spread receives buy confirmations for one each of the four EB contracts in the Red Pack, at prices equal to their respective previous daily settlement prices minus 10 ticks, and sell confirmations for one each of the four EB contracts in the Green Pack, at prices equal to their respective previous daily settlements minus 18 ticks. The seller of the Pack spread gets the obverse set of confirmations.

The Red-Blue-Purple 2-year Pack butterfly trades at +14.75 ticks. The relatively nearby Red and Blue Packs get booked at their Pack C-Last prices. Suppose these are, respectively, -10 ticks and -25.5 ticks. The most deferred component of the butterfly, the Purple Pack, gets booked at the derived price of -26.25 ticks, equal to (butterfly price) minus (Red Pack price) plus (2 x Blue Pack price), or (+14.75 ticks) minus (-10 ticks) plus (2 x -25.5 ticks). For each Pack the assigned price is then distributed to the Pack's member futures contracts.

CME Globex Trade Matching Algorithms for EB Futures

CME Globex matches every EB futures trade according to one of two matching algorithms, depending upon the contract or spread or combination being transacted. Before taking a closer look at these, two bits of nomenclature are worth establishing.

Resting Orders versus Aggressor Orders

A resting order is a posted actionable bid or offer at a given price for a given number of futures contracts (or for a given number of Bundles or Packs or other defined strategies). An aggressor order is either a sell order that entails hitting resting bid orders, or a buy order that entails lifting resting offered orders.

TOP Order

…is the first order to improve the market – ie, to achieve a higher resting best bid or a lower resting best offer -- at a given prevailing price level. TOP order designation ensures that any order that seizes the initiative in improving its side of the market will be filled before other resting orders on the same side of the market.[16] Both the bid side and the offered side of the market may simultaneously have TOP orders. At any given moment, however, no more than one buy order and no more than one sell order can hold TOP designation.

On either side of the market, there may not always be a TOP order. Suppose for example that an incoming resting buy order improves the market and becomes TOP bid. If that order is subsequently cancelled, TOP status does not automatically pass to another resting bid already in the order book. Rather, TOP designation will be conferred upon the next arriving buy order that improves upon the prevailing best bid price. The same applies on the offered side of the market.

Contracts, Calendar Spreads, Butterflies, Double Butterflies, Condors, Pack Spreads, and Pack Butterflies

…are matched by the "Pro Rata Allocation with TOP Price" (or A) algorithm. In essence, the A algorithm distributes an incoming aggressor order pro rata to resting orders at the best price, with deference to the TOP order if there is one. Specifically:

> (a) When there is a TOP order, the aggressor order is assigned to it first.
>
> (b) Any unfilled portion of the aggressor order is then matched to other resting orders at the best price, on a pro rata basis. At any given resting price level each resting order's pro-rated percentage is calculated by dividing its order quantity by the total quantity of all resting orders at that price level. Any unfilled portion of the aggressor order remaining after Step (a) is then multiplied by each resting order's pro-rated percentage.
>
> (c) The quantity allocated to each resting order is the result from Step (b) rounded down to the nearest integer number of contracts. For any resting order to which the rounded-down allocation would be less than two contracts, the quantity assigned is zero.
>
> (d) Any unfilled portion of the aggressor order that remains after application of Steps (b) and (c) is then assigned on a FIFO basis.

If there is no TOP order, the process starts with Step (b).

[16] Among other of the Exchange's futures contracts, TOP order status may be governed by a minimum, whereby an order that improves the market is designated as TOP only if its size meets or exceeds a specified minimum threshold. Likewise, for some contracts, TOP order status is subject to a maximum, whereby the TOP order enjoys priority in getting filled only up to a specified amount. In many instances, both a minimum and a maximum apply.

Exhibit 5 illustrates how the algorithm would work where a hypothetical aggressor sell order for 633 contracts meets five resting orders at the best bid, as described in Columns 1 and 2. ("Contract" is used loosely to signify either an individual EB futures contract or any of the combinations listed above.)

Exhibit 5
Algorithm A – Pro Rata Allocation with TOP Price. Aggressor Order = 633 Contracts.
(Number of Contracts, Unless Otherwise Noted)

(1) Resting Orders at Best Bid, by Time Priority	(2) Order Size	(3) **TOP Allocation**	(4) Resting Orders after TOP Allocation = (2)–(3)	(5) Pro Rata Allocation Percentage	(6) **Pro Rata Allocation** = (4)x(5)	(7) Resting Orders after Pro Rata Allocation = (4)–(6)	(8) **FIFO Allocation**	(9) Total Allocation = (3)+(6)+(8)
1 – TOP	150	150						150
2	5		5	5 / 3005		5	2	2
3	1000		1000	1000 / 3005	160	840		160
4	500		500	500 / 3005	80	420		80
5	1500		1500	1500 / 3005	241	1259		241
Total		150			481		2	633

Source: CME Group

The five resting orders at the best price signify total depth at the best bid equal to 3,155 contracts. Proceeding as above --

(a) The highest-priority resting order, for 150 contracts, holds TOP status (Column 1). It gets matched first, in this case in its entirety (Column 3).

(b) The remaining 483 contracts in the aggressor order are distributed pro rata across the 3,005 contracts that remain among resting orders at the best price level (Column 5). Each pro rata allocation is rounded down to the nearest integer number of contracts. Note that the allocation to the second resting order in terms of time priority is less than two contracts and is therefore rounded down to zero (Column 6).

(c) The remaining 2 contracts in the aggressor order are distributed FIFO. The second resting order in terms of time priority, for 5 contracts, absorbs this assignment (Column 8).

Column 9 summarizes the resultant distribution of the aggressor sell order among the resting bid orders.

Packs, Bundles, Month-Pack Spreads, and Bundle Spreads

…are matched by the "FIFO with LMM" (or T) algorithm. The T algorithm first allocates any aggressor order to designated lead market makers (LMMs), after which the remaining unmatched portion of the aggressor order gets matched on a FIFO basis.

Exhibit 6 illustrates with another hypothetical example. As in Exhibit 5, an aggressor sell order for 633 contracts meets five resting orders at the best bid, as specified in Columns 1 and 2. (Note that "contract" denotes a combination – a Pack, Bundle, month-Pack spread, or Bundle spread – rather than an individual EB futures contract.) Moreover, the resting orders in Exhibit 6 include bids posted by a cadre of lead market makers, each of whom is assumed to be entitled to a 15 percent share of any aggressor order; each such share allocation gets rounded down to the nearest integer number of contracts.

Accordingly, each of the three LMMs is allocated 94 contracts, equal to 15 percent of 633 contracts (Column 3). The remaining 351 contracts in the aggressor order are then assigned on a FIFO basis (Column 5). Column 6 summarizes how the algorithm distributes the aggressor sell order among the resting bid orders.

Exhibit 6
Algorithm T – FIFO with LMM. LMM Allocation = 15%. Aggressor Order = 633 Contracts.
(Number of Contracts, Unless Otherwise Noted)

(1) Resting Orders at Best Bid, by Time Priority	(2) Order Size	(3) **LMM Allocation** = 0.15 x 633	(4) Resting Orders after LMM Allocation = (2)–(3)	(5) **FIFO Allocation**	(6) Total Allocation = (3)+(5)
1 – LMM	150	94	56	56	150
2	5		5	5	5
3 – LMM	1000	94	906	290	384
4 – LMM	500	94	406		94
5	1500		1500		
Total		282		351	633

Source: CME Group

CME Group

FUTURES RATES, FORWARD RATES, AND CONVEXITY BIAS

A close cousin of the EB futures contract is the three-month euro forward rate agreement (FRA), which trades in both over-the-counter interbank markets and dealer-to-customer markets for treasury management products. Despite numerous similarities, EB futures and euro FRAs are by no means identical. Among the salient distinctions between them is that their market values respond differently to interest rate volatility.

The upshot of this difference is that EB futures contract rates systematically exceed the forward interest rates at which the corresponding FRAs are priced. Market practitioners refer to this phenomenon as the convexity bias in EB futures prices.

Where convexity bias comes from

The EB futures contract is defined so that its response to interest rate changes is linear. To be precise, the contract's PV01 with respect to its reference forward three-month interest rate is always €25.

FRAs, by contrast, are customarily priced and marked so that their response to interest rate changes is convex. That is, an FRA's PV01 with respect to its reference forward three-month interest rate is the present value of approximately[17] €25 per basis point of change in the rate.

A direct consequence of this distinction is that EB futures buyers do not enjoy the benefit of being owners of convexity, as they would if they owned the corresponding interest rate exposures in FRA form. For this reason, EB futures are systematically priced at a discount relative to the hypothetical price that would be determined as 100 minus the corresponding FRA forward rate. In other words, EB futures contract rates, at fair value, are systematically higher than their corresponding FRA forward rates. The difference (EB futures contract rate minus FRA forward rate) is known as the convexity bias correction:

EB futures contract rate = "true" FRA forward rate + convexity bias correction

Determinants and a rule of thumb

As a general proposition the magnitude of the convexity bias correction for EB futures contracts grows larger as:

(1) the term between today and the EB futures expiry date lengthens; or
(2) volatility increases in the forward-starting interest rate that the EB contract references; or
(3) volatility increases in the spot rate used to determine the present value of changes in the EB contract's forward-starting interest rate; or
(4) the degree of correlation increases between movements in the forward interest rate in (2) and movements in the spot rate used for discounting to present value in (3).

Of these four factors, (1) and (2) loom largest. A popular rule of thumb elegantly and conveniently captures their interrelationship:

Convexity bias = $(\sigma^2/2) \times t \times T$

where

t = term from present to EB futures expiration (in years)
T = t + 3 months (ie, t + 0.25 years)
σ = volatility of the forward interest rate for a notional interbank deposit for forward settlement on date t and for maturity three months later on date T

[17] The FRA's PV01 is the present value of exactly €25 per basis point if the FRA's forward-starting three-month interval spans 90 days. Otherwise, the FRA's DV01 is the present value of some other slightly different amount per basis point. See **Notional Contract Size = €1 Million … More or Less** on page 6.

By way of example, consider the First Gold EB contract, for delivery 4.25 years hence. Suppose that σ for the corresponding forward interest rate equals 100 basis points per annum (approximately 6.3 basis points per day, equal to (100 bps per annum) / (252 business days per annum)$^{1/2}$). Then:

$\sigma^2 = 0.0001 = 0.01^2 = (100 \text{ basis points})^2$
$t = 4.25$ years
$T = 4.5$ years

Accordingly, the convexity bias is equal to:

$$0.000956 = (0.0001 / 2) \times 4.25 \times 4.5$$

or 9.56 basis points per annum.[18]

[18] For an excellent discussion of the rule of thumb, see John Hull, **Options, Futures, and Other Derivatives, 7th Edition**, Pearson Prentice Hall, 2009, especially Chapters 6 and 30.

APPENDIX: A CONCISE GUIDE TO EURIBOR®

Euribor® is the rate – more precisely, the term structure of rates -- at which euro-denominated interbank term deposits are offered by one prime bank to another within the European Monetary Union (EMU) at 11am Brussels time. Euribor® is calculated and published each day, apart from Saturdays, Sundays, and TARGET system holidays.

The following overview describes the Euribor® mechanism. Unless otherwise noted, the information source is Euribor® EBF (www.euribor-ebf.eu).

Euribor® Governance and Panel Banks

Euribor® was introduced at the end of 1998 under the auspices of the European Banking Federation (EBF) and the Financial Markets Association (Association Cambiste Internationale, or ACI). A strict Code of Conduct sets out rules covering, among other things, the criteria for determining which banks may belong to the Euribor® panel and the obligations of the panel banks.

Article 7 of the Euribor® Code of Conduct also authorizes a 10-member Steering Committee to oversee the Euribor® mechanism. The Secretary General of EBF is a permanent member, while the other nine are market practitioners who serve terms of two years, which are renewable.

Among the Steering Committee's responsibilities is to conduct periodic reviews of panel banks, to ensure that each panelist upholds the standards for panel membership, and that its conduct is generally supportive of the Euribor® mechanism.

The Steering Committee also is charged to consider applications for Euribor® panel membership. Any bank may apply for membership, if it is possessed of high credit standing and good reputation and is demonstrably active in euro-denominated money markets, and if it operates at least one branch or subsidiary in at least one nation within the euro zone. The candidate must be willing and able to furnish the Steering Committee with detailed information in regard to the criteria that form the basis for admission to panel membership:

(1) *scale of trading activity in euro money markets*, in both normal and turbulent market conditions, in both:

(2) *balance-sheet items* such as loans and deposits at tenors up to one year, money market instruments such as CDs and CP, and repurchase agreements, and

(3) *off-balance-sheet items* such as euro-based interest rate derivatives (both exchange-listed and over-the-counter) and euro-related foreign exchange swaps.

Finally, the Steering Committee is responsible to review, and if necessary to adjust, the size of the Euribor® panel, not just to ensure efficient functioning of the Euribor® mechanism, but also to see that the panel adequately reflects the EMU's geographic diversity. The 44 institutions currently serving as panel banks are shown in Exhibit A1.

CME Group

Exhibit A1 -- Euribor® Panel Banks, August 2011

Austria	***Ireland***
Erste Group Bank	AIB Group
RZB	Bank of Ireland
Belgium	***Italy***
Dexia Bank	Intesa Sanpaolo
KBC	Monte dei Paschi di Siena
	Unicredit
Finland	
Nordea	***Luxembourg***
Pohjola	Banque et Caisse d'Épargne de l'État
France	***Netherlands***
Banque Postale	ING Bank
BNP Paribas	RBS NV
HSBC France	Rabobank
Société Générale	
Natixis	***Portugal***
Crédit Agricole	Caixa Geral De Depósitos
Crédit Industriel et Commercial	
	Spain
Germany	BBV
Bayerische Landesbank	Banco Santander
Commerzbank	CECA
Deutsche Bank	La Caixa Barcelona
DZ Bank	
Landesbank Baden-Württemberg	***Other EU***
Landesbank Berlin	Barclays Capital
Landesbank Hessen-Thüringen	Den Danske Bank
Norddeutsche Landesbank	Svenska Handelsbanken
WestLB	
	International
Greece	UBS (Luxembourg) SA
National Bank of Greece	Citibank
	JP Morgan Chase
	Bank of Tokyo Mitsubishi

Source: www.euribor-ebf.eu

The Euribor® Standard

On each day the TARGET system is open, Euribor® is set for Eurozone interbank placements at 15 terms to maturity: 1-week, 2-week, 3-week, and all monthly maturities from 1-month to 12-month, inclusive.

(1) Interest rate

For each term to maturity, each panel bank submits the interest rate that, to the best of the bank's knowledge, represents "the best price between the best banks," ie, the rate:

(1a) at which the bank perceives euro-denominated term deposits to be offered, within the EMU zone, by one prime bank to another at 11am Brussels time.

(1b) that is understood to be quoted on an actual/360 day count basis.

(1c) for which the interest rate per annum is quoted to three decimal places of precision, ie, to the nearest 1/10th of one basis point per annum.

(2) Settlement dates

The deposit rate must be quoted for spot (T+2) settlement, ie, two TARGET business days after "today."

(3) Maturity date

(3a) *For 1-week, 2-week, and 3-week terms to maturity*
The maturity date is always the first TARGET business day that falls at least 7, 14, or 21 days, respectively, from the deposit settlement date.

(3b) *For monthly terms to maturity (1-month to 12-month, inclusive)*
The maturity date is the TARGET business day on or after the date, within the month of maturity, that corresponds to the deposit settlement date.

> ***Standard Procedure***
> If the corresponding date in the month of maturity is not a TARGET business day, then the maturity date gets pushed back to the next following TARGET business day.
>
> ***Exception 1: Modified Next Business Day***
> If, and only if, the Standard Procedure pushes the maturity date into the next calendar month, then the maturity date gets pulled forward to the first preceding TARGET business day.
>
> ***Exception 2: End-End***
> If the deposit's settlement date is the final business day of the calendar month, then the maturity date is always set to the last TARGET business day of the month of maturity, rather than the corresponding date within the month of maturity. For example, in a non-leap year, a one-month deposit that settles on 28 February is understood to mature on 31 March, not on 28 March (assuming 28 February, 28 March, and 31 March are all TARGET business days).

Exhibit A2 illustrates how the Modified Next Business Day and End-End provisions would apply in the determination of maturity dates for one-month interbank placements made in late January 2009.

Exhibit A2 –
Settlement Date and Maturity Date Examples for 1-Month Interbank Placements, Jan 2009

Quote Date and Euribor® Fixing Date	Settlement Date	Maturity Date	Applicable Term to Maturity Rule
Mon, 26 Jan	Wed, 28Jan	Fri, 27 Feb	Modified Next Business Day
Tue, 27 Jan	Thu, 29 Jan	Fri, 27 Feb	Modified Next Business Day
Wed, 28Jan	Fri, 30 Jan	Fri, 27 Feb	End-End
Thu, 29 Jan	Mon, 2 Feb	Mon, 2 Mar	Standard Procedure
Fri, 30 Jan	Tue, 3 Feb	Wed, 3 Mar	Standard Procedure

Source: CME Group

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> (3) rounding the trimmed average in Step (2) to three decimal places, ie, to the nearest 1/10th of one basis point per annum.

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