Money Calculations for CME-cleared Futures and Options
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Variation calculations for futures

For futures, **mark-to-market amounts** are called **settlement variation**, and are banked in cash every day. We say that for futures, there is a **daily cash mark-to-market**. Settlement variation amounts are also called **variation margin** or simply **variation**. Note that the description herein applies to all products which are futures from a functional point of view, including some which may not be considered futures from a regulatory point of view.

For each position on each clearing business day, the total variation amount is calculated as the sum of:

- The mark-to-market amounts on **each trade cleared** on that day, **from trade price** to that day's end-of-day settlement price, plus

- The mark-to-market amount on the **start-of-day position**, from the **previous day's settlement price** to that day's end-of-day settlement price.

There are two methods for calculating these mark-to-market amounts, differing from each other in where rounding is done: **normal futures rounding**, or **special rounding for notional products**.

Normal futures rounding

Most futures products use normal futures rounding. Here's how it works for calculating the mark-to-market amount on a cleared trade:

- Take the end-of-day settlement price for the contract. Multiply by the contract value factor. Round this result normally to the normal precision of the contract's settlement currency. This yields the **rounded monetary value for one contract at the settlement price.**

- Take the trade price for this trade. Multiply by the contract value factor. Round this result normally to the normal precision of the contract's settlement currency. This yields the **rounded monetary value for one contract at the trade price.**

- Subtract the rounded monetary value for one contract at the trade price, from the rounded monetary value for one contract at today's settlement price.

- Multiply this difference by the trade quantity, expressed as a positive number for a buy or a negative number for a sell.

For the start-of-day position, the process is exactly analogous:

- Take the end-of-day settlement price for the contract. Multiply by the contract value factor. Round this result normally to the normal precision of the contract's settlement currency. This yields the **rounded monetary value for one contract at the settlement price.**

- Take the **previous day's** end-of-day settlement price for the contract. Multiply by the contract value factor. Round this result normally to the normal precision of the contract's settlement currency. This yields the **rounded monetary value for one contract at the previous day's settlement price.**

- Subtract the rounded monetary value for one contract at the previous day's settlement price, from the rounded monetary value for one contract at today's settlement price.

- Multiply this difference by the net start-of-day position quantity, expressed as a positive number for a net long position or a negative number for a net short position.

In effect, we're determining the **rounded money value at <u>each</u> price point.** Then we take the value difference and multiply by the quantity. The reason for doing it this way is to ensure that you get the same result regardless of how you break up the quantities. For example, the total variation on seventeen one lot's will be the same as the variation on one seventeen-lot. Also, you get the same result regardless of whether you mark things directly to the final price, or whether you go through intermediate marking points.

Several items to note:

- The result is a positive money value for a gain (a "variation collect") or a negative value for a loss (a "variation pay"). The sign convention is from the point of view of the clearing firm, or the customer of the clearing firm.

- The **normal precision** of the settlement currency is two decimal places – *ie,* to the penny – for most currencies such as USD, EUR, GBP. For a few currencies such as JPY, the normal precision is zero decimal places. In other words, values are calculated to the whole yen.

- **Normal rounding** means that values that are precisely equidistant between two points are rounded **up** – *ie,* **away from zero**. Here's some examples that make things clear:

  For USD-denominated amounts:

32.5649	is rounded to	32.56
32.5650	is rounded to	32.57
32.5651	is rounded to	32.57
-32.5649	is rounded to	-32.56
-32.5650	is rounded to	-32.57
-32.5651	is rounded to	-32.57

  For JPY-denominated amounts:

3,256.49	is rounded to	3,256
3,256.50	is rounded to	3,257
3,256.51	is rounded to	3,257
-3,256.49	is rounded to	-3,256
-3,256.50	is rounded to	-3,257
-3,256.51	is rounded to	-3,257

- For some products, quoted prices are expressed in non-decimal formats. For example, for CBOT Treasury note futures, prices may be expressed in 32nds and quarter 32nds, and for some CBOT grain futures, prices may be expressed in dollars and cents and eighth's of a cent per pound.

  For products with prices like these, the first step is to decimalize the price with no loss of precision. For example, suppose a Treasury note future where the price is 110 and 5 and three-quarter 32nds. Take 5.75 and divide by 32, yielding 0.1796875. Add 110, yielding 110.17796875. This is the value that is then further used for the mark-to-market calculations.

For the vast majority of futures products, when you multiply the price by the contract value factor, you get a money value where no rounding is necessary. Whether rounding is needed is determined by (a) the minimum fluctuation in price (the "tick"), and (b) the contract value factor. But for some you can get unrounded money values smaller than the minimum precision of the currency. For example, for CBOT Two-Year Treasury Note futures, or CBOT Fed Fund futures, you can get a money value to 0.005 – *ie,* half a penny. In this case, the rounding is needed. For consistency when doing the calculations for normal futures, we do the rounding in all cases.

Special futures rounding for notional products

Some futures products may be traded in **notional** terms, which is another way of saying that the contract size is very small. For example, you could have an FX futures contract on the exchange rate between EUR and JPY, where the contract size is one EUR. So the trade quantity would be the notional amount of the trade, and the contract value factor is 1.0.

For these types of futures, the normal rounding method introduces too much distortion into the mark-to-market calculations, and hence we use **special (notional) futures rounding.** For example, to calculate the mark to market amount for a trade:

- Subtract the trade price from the end-of-day settlement price.
- Multiply by the trade quantity and by the contract value factor.
- Round normally to the normal precision of the settlement currency.

For the start-of-day position, the calculation is exactly analogous, except that you're subtracting the previous day's end-of-day settlement price from today's end-of-day settlement price, and using the net start-of-day position rather than the trade quantity.

"Futures Inverse" Money Calculations

For some currency futures, the convention for quoting the price and quantity, together with the normal method of calculating variation, may result in variation amounts being denominated in a currency which is not normally bankable by market participants.

For these futures, the "futures inverse" method is used to calculate settlement variation. The method divides by the appropriate spot exchange rate, thereby flipping the currency of denomination from the non-bankable to the bankable currency.

An example is CME's **CNY** and **MNY** futures, on the exchange rate between the US Dollar and the Chinese Renminbi Yuan. For the **CNY** contract, the contract size is 100,000 USD and the price is quoted in CNY (Chinese Renminbi Yuan) per US dollar. If variation were calculated via the normal method, it would be denominated in CNY, which is not normally bankable by US market participants. Hence we use the "futures inverse" method to flip the currency of denomination from CNY to USD.

The process is driven by a value of **FUTI** ("futures inverse") for the product's valuation method.

For example, suppose you are calculating the mark-to-market on a trade which is a sell of five contracts at a trade price of 6.1234 CNY per USD. Suppose further that the end-of-day settlement price for the contract is 6.5678 CNY per USD, and that the end-of-day exchange rate is set by CME Clearing at 6.9012 CNY per USD. The mark-to-market in USD would be calculated as:

Settlement price of 6.5678 less Trade Price of 6.1234
Times quantity of -3
Times contract value factor of 100,000
Divided by the exchange rate of 6.9012
Yielding an unrounded value of -19,318.37941 USD
Which is then rounded normally to -19,318.38.

Note that the exchange rate selected must be the **multiplier** used to convert a value from the primary currency of the pair – USD in this case – to the contra currency (CNY in this case.)

For more information please see Clearing Advisory 12-319, published July 26, 2012, at:
http://www.cmegroup.com/tools-information/lookups/advisories/clearing/files/Chadv12-319.pdf

Premium calculations for options

Most CME Group options are **premium-style**, meaning that the purchaser pays the full premium in cash and the seller receives the full premium in cash. The calculation of the premium amount uses either **normal rounding** or **special notional rounding**, in a manner exactly analogous to that for futures.

Normal rounding

For normal option products, you calculate the option premium as follows:

- Take the trade price.
- Multiply by the contract value factor.
- Round normally to the normal precision of the settlement currency. Then flip the sign, yielding the premium for a purchase of one contract.
- Express the trade quantity as a positive number for a buy or a negative number for a sell, and multiply by the above value.

So just as for futures, you're calculating the rounded monetary value of **one** contract at the trade price, and then scaling up by the contract size. The flipping of the sign is because the buyer of the option is paying premium, and the seller is receiving.

Special notional rounding

Exactly as for futures, some option products may have a very small contract size, and for these, the results are distorted if you round when you calculate the premium for one contract. Therefore, for these options:

- Take the trade price.
- Multiply by the contract value factor.
- Express the trade quantity as a positive number for a buy or a negative number for a sell, and multiply by the above value.
- Take the product of these three values, flip the sign, and round normally to the normal precision of the settlement currency.

Exactly as for futures, for most options, you get the same results regardless of where you do the rounding. But for products such as options on Treasury futures, it's vital to use normal rounding, and for other contracts such as options on FX where trade quantities are in notional, it's vital to use special notional rounding.

Variation and premium amounts for Futures-Style options

A **futures-style option** behaves in a manner analogous to that of a deliverable futures contract.

The premium is assessed at the point where the option position is removed, whether by exercise, assignment or expiration, at the settlement price of the option on the day that the position is removed. There is no premium assessed on trade date, except if the option were immediately exercised, assigned or expired.

Prior to expiration, settlement variation is calculated in a manner exactly identical to that of a future. On trade date, the option is marked from trade price to that day's settlement price, and on subsequent days, the mark to market is done from the previous day's settlement price to the new day's settlement price.

Note that the current market value of a futures-style option does **not** increment or decrement the total performance bond (initial margin) requirement, unlike that of a premium-style option.

Note also that the final settlement price of an out of the money futures style option will normally be zero, reflecting that no premium will move when option positions expire unexercised or unassigned.

A futures-style option will have a valuation method of **FUT**, exactly like that of a future.

Calculating final settlement amounts for true cash-settled options

Most options are physically-delivered. For example, for an option on a future, when the option is exercised or assigned, you create a transaction in the underlying future at the strike price.

Some options, however, are **true cash-settled**: when exercised or assigned, you simply create a cash movement which is banked with the option position. The calculation of this amount is exactly analogous to calculating variation on a futures trade, and indeed the amount is considered to be settlement variation.

If using normal rounding

- Take the end-of-day settlement price for the underlying contract. Multiply by the contract value factor, and round normally to the normal precision of the settlement currency, yielding the rounded monetary value of one contract at the underlying's settlement price.

- Take the strike price. Mutliply by the contract value factor, and round normally to the precision of the settlement currency, yielding the rounded monetary value of one contract at the strike price.

- Subtract the rounded monetary value at the strike price from the rounded monetary value at the underlying's settlement price.

- Express the quantity as a positive number for an exercise of a call or an assign of a put, or a negative number for an assign of a call or an exercise of a put.

- Multiply the money difference by the quantity.

If using special notional rounding

- Subtract the strike price from the underlying's end-of-day settlement price.

- Express the quantity as a positive number for an exercise of a call or an assign of a put, or a negative number for an assign of a call or an exercise of a put.

- Take the product of the price difference, the quantity and the contract value factor, and round normally to the normal precision of the settlement currency.

If using the "equity inverse" method

The analog of the "futures inverse" calculation method for futures, is the "equity inverse" method which would be applied to the calculation of option premium, for example, for an option on the CME's **CNY** future. This would be driven by a valuation method of **EQTYI**.

The calculation is exactly the same as the "special notional rounding" method specified above, except that it includes a division by the exchange rate (the multiplier) used to convert from the primary currency of the pair to the contra currency.

Calculating daily adjustment amounts for certain futures contracts

Some futures contracts have a **daily adjustment** cash flow in addition to normal settlement variation. For some contracts, this may be thought of as an interest-rate passthrough, and for others, as an embedded fee.

For each such contract, at the end of each business day, in addition to the normal end-of-day settlement price, two values are published: the **daily value adjustment rate for long positions**, and the **daily value adjustment rate for short positions**. These are typically abbreviated as the **DVA rate for longs** and the **DVA rate for shorts**.

DVA rates may be positive, negative, or zero. For historical reasons, a positive number is often referred to as a **discount** value, and a negative number as a **premium** value.

To calculate the daily adjustment amount:

- Express the position quantity as a positive number for a long position, or a negative number for a short position.
- Take the appropriate DVA rate – either the DVA rate for longs or the DVA rate for shorts.
- Take the product of the position quantity, the DVA rate, and the contract value factor.
- If this result is a negative number (a pay), round up (away from zero) to the normal precision of the settlement currency. If it's a positive number (a collect), then round down (towards zero) to the normal precision of the settlement currency.

Transferring daily adjustment amounts

If you're transferring an open trade in a future with a daily adjustment, you may wish to transfer the cumulative daily adjustment amount that has been realized since the original trade date, along with the trade. Similarly, if you are clearing an as-of trade, you may wish to calculate and bank the cumulative daily adjustment amount from the original trade date.

To facilitate this, for every contract with a daily adjustment, on every business date we publish the cumulative daily adjustment rates for each prior business date since the contract's inception. For each such prior business date, there will be a **cumulative daily adjustment rate for long positions**, and a **cumulative daily adjustment rate for short positions.** These are abbreviated as the **cumulative DVA rate for longs**, and the **cumulative DVA rate for shorts.**

The cumulative rate represents the sum of the DVA rates from the specified trade date, up to (but not including) the current date.

For each such transfer or as-of transaction, you calculate the cumulative daily adjustment amount as follows:

- Express the trade quantity as a positive number for a buy, or a negative number for a sell.
- Take the appropriate cumulative DVA rate – either the cumulative DVA rate for longs or the cumulative DVA rate for shorts – for the specified original trade date.
- Take the product of the trade quantity, the cumulative DVA rate, and the contract value factor.
- If this result is a negative number (a pay), round up (away from zero) to the normal precision of the settlement currency. If it's a positive number (a collect), then round down (towards zero) to the normal precision of the settlement currency.

The total daily adjustment amount is then determined as the sum of the cumulative adjustment amount on all transfers and/or as-of transactions, plus the normal daily adjustment amount for the position.

Data elements

There are two key data elements which drive these calculation processes, the **product type code** and the **valuation method code**. All products which have daily adjustments have a product type code of **FUT**, and a valuation method code **FUTDA** (futures-style with a daily adjustment).

The product type code and valuation method code can be read from the SPAN file and/or the FIXML Product Reference File. In the XML- format SPAN file, the valuation method for a futures product is provided in the **valueMeth** attribute, and in the positional-format SPAN file, the value is provided on the type "P" record.

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