ICE Benchmark Administration

Calculation of ICE Swap Rate from Tradeable Quotes

Overview

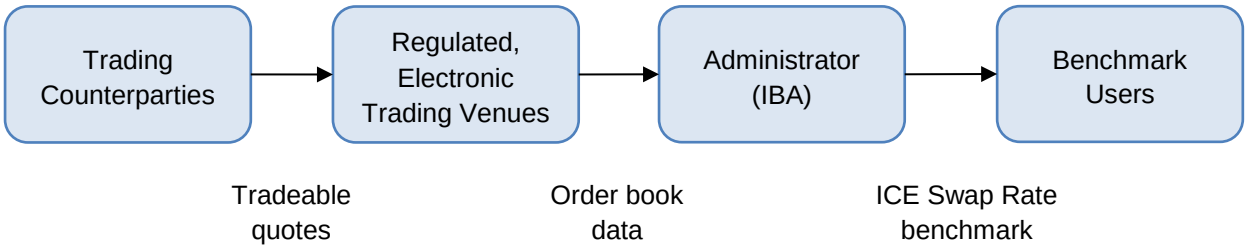
The ICE Swap Rate benchmark represents the mid-price for interest rate swaps (the fixed leg), in various currencies and tenors and at particular times of the day.

ICE Swap Rate is calculated off tradeable quotes from regulated, electronic, multilateral trading venues.

In essence, the new calculation works out what mid-price you would get if you were to fill a trade of Standard Market Size[1] using the best prices available on the trading venues at the relevant times and in the relevant currencies and tenors. This document describes the new calculation.

This methodology is reviewed by the ICE Swap Rate Oversight Committee as documented in its Terms of Reference. The frequency of reviews is set by the Oversight Committee through its Calendar of Agenda Items.

Structure



Abbreviations

- VWB – Volume Weighted Bid
- VWO – Volume Weighted Offer
- VWAMP – Volume Weighted Average Mid Price
- SMS – Standard Market Size, the volume for the standardised trade to be filled

[1] N.B. The 'filling' is a theoretical filling done as part of the calculation; the administrator does not actually trade in the market. Standard Market Sizes are different for each currency and tenor, and are detailed in Appendix 1

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Key features of the Calculation

- **VWAMPs from Synthetic Order Books at Snapshots in Time**: the calculation is based on finding the VWAMP from theoretically filling a trade in SMS on both the bid and offer side at a particular instant in time (a snapshot). At each snapshot, we combine the order books from all the trading venues to create a synthetic order book that represents the best prices (and accompanying volumes) available in the market at that time. We then calculate the volume weighted prices at which you could fill a trade in SMS from this synthetic order book on both the bid and offer side and these effective prices are used to calculate the VWAMP.

- **Multiple Snapshots:** instead of using just one snapshot at a pre-determined time to create the VWAMP, IBA uses multiple, randomised snapshots taken in a short window before the calculation. This makes the benchmark more robust against attempted manipulation and momentary aberrations in the market.

- **Liquidity Checks**: illiquid snapshots are not included in the calculation – any snapshots that can't fill the SMS (on both the bid and offer side) are discarded, so only VWAMPs from reasonably sized trades are included in the calculation. A minimum number of liquid snapshots is required to perform the calculation.

- **Outlier Checks:** to protect against momentary and unrepresentative spikes in price, outlier snapshots are not included in the calculation. The snapshots that pass the liquidity checks are ranked in order of their VWAMPs and the snapshots higher than the 75th percentile and lower than the 25th percentile are discarded leaving only the most representative snapshots.

- **Quality Weighting:** IBA combines the remaining VWAMPs into a final price (ICE Swap Rate) using a quality weighting. Snapshots with tighter spreads between the VWB and VWO are indicative of a better quality market so are given a higher weighting.

- **Movement Interpolation:** Where there are not enough liquid snapshots to calculate the rate for a tenor, the day-on-day move in adjacent tenors and the previous day's rate for the tenor are used to interpolate a rate (provided certain conditions are met).

Step by Step Calculation

The calculation has 4 steps:

1. Take multiple snapshots, create a synthetic order book for each snapshot and calculate each VWAMP
2. Discard illiquid snapshots

If there are enough liquid snapshots:

3. Discard outlier snapshots
4. Quality-weight the remaining snapshots (VWAMPs) to give the ICE Swap Rate

If there are not enough liquid snapshots:

5. Use movement interpolation to give the ICE Swap Rate (provided certain conditions are met)

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Step 1: Take multiple snapshots, create a synthetic order book for each snapshot and calculate each VWAMP

IBA collects data for a two minute window in the run up to an ICE Swap Rate calculation (e.g. 10:58am to 11:00am). This data contains the tradeable prices and volumes that were available on the trading venues during the window.

To generate the randomised snapshot times, the calculation divides the two minute window into 24 blocks of 5 seconds each and generates a random snapshot time (to the nearest millisecond) in each of these 5 second blocks. This ensures that there is adequate spacing between most of the snapshots because, while any two snapshots could randomly be close together (either side of a block 'boundary'), three snapshots can't all be close to each other (there will always be a whole 5 second block separating the outer two). So the snapshots will be spaced appropriately through the window.

At each snapshot time we create a synthetic order book from all of the prices and volumes that were tradeable across any venue at that moment in time. We rank the bids and offers by price and use these quotes to calculate what the VWB, VWO and VWAMP would be if you were to fill a trade of SMS.

The below example assumes a standard market size of 50 million, taking data from three trading venues at one snapshot time (for one currency and tenor, and only showing the top 5 price levels from each venue)[2]:

Generating the synthetic order book from one snapshot:

Trading Venue 1			
Bid		**Offer**	
Vol (m)	Price	Price	Vol (m)
16	1.4530	1.5400	30
32	1.4360	1.5630	49
13	1.3730	1.6210	28
23	1.3050	1.6520	50
37	1.2980	1.7100	44

Trading Venue 2			
Bid		**Offer**	
Vol (m)	Price	Price	Vol (m)
32	1.4590	1.5480	17
40	1.4050	1.5660	19
17	1.3740	1.6250	31
39	1.3340	1.6820	30
33	1.2830	1.7210	28

Trading Venue 3			
Bid		**Offer**	
Vol (m)	Price	Price	Vol (m)
19	1.4500	1.5260	23
35	1.4490	1.5750	26
36	1.3850	1.6320	40
39	1.3180	1.6920	42
49	1.2660	1.7430	44

Synthetic Order Book			
Bid		**Offer**	
Vol (m)	Price	Price	Vol (m)
32	1.4590	1.5260	23
16	1.4530	1.5400	30
19	1.4500	1.5480	17
35	1.4490	1.5630	49
32	1.4360	1.5660	19

Order taken from venue 1 Order taken from venue 2 Order taken from venue 3

[2] We use the full granularity of each price during the calculation and we round the final output to three decimal places for the publication of the final ICE Swap Rate. To simplify the example we are only showing granularity to 4 decimal places during the calculation.

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From this Synthetic Order Book we then identify the price levels that cumulatively allow us to fill the Standard Market Size (in this case 50m):

Identifying the volumes and price levels to use to simulate filling an order of SMS :

Synthetic Order Book					
Bid			**Offer**		
Vol used for SMS (m)	Vol (m)	Price	Price	Vol (m)	Vol used for SMS (m)
32	32	1.4590	1.5260	23	23
16	16	1.4530	1.5400	30	27
2	19	1.4500	1.5480	17	
	35	1.4490	1.5630	49	
	32	1.4360	1.5660	19	

Price level used in 'filled' trade of SMS

We then simulate filling an order of SMS (e.g. 50m) by calculating the volume weighted prices on the bid and offer side (VWB and VWO) using the volumes and price levels that we identified. In this case:

$$VWB = \frac{32}{50} \times 1.4590 + \frac{16}{50} \times 1.4530 + \frac{2}{50} \times 1.4500 = 1.4567$$

$$VWO = \frac{23}{50} \times 1.5260 + \frac{27}{50} \times 1.5400 = 1.5336$$

And the VWAMP is the mid-point of the Volume Weighted Bid and Volume Weighted Offer:

$$VWAMP = \frac{1.4567 + 1.5336}{2} = 1.4952$$

So for this snapshot:

- VWB = 1.4567
- VWO = 1.5336
- **VWAMP = 1.4952**

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We repeat this process of creating a synthetic order book and calculating the VWAMP for each of the 24 snapshot times:

Snapshot Time	VWB	VWO	VWAMP
10:58 02s 125ms	1.4567	1.5336	**1.4952**
10:58 07s 145ms	1.4935	1.5062	**1.4999**
10:58 12s 568ms	1.4859	1.5092	**1.4976**
10:58 19s 821ms	1.4962	1.5051	**1.5007**
10:58 20s 125ms	1.4967	1.5034	**1.5001**
10:58 28s 855ms	1.4812	1.5151	**1.4982**
10:58 31s 005ms	1.4967	1.5028	**1.4998**
10:59 38s 599ms	1.4989	1.5005	**1.4997**
10:58 44s 525ms	1.4922	1.5092	**1.5007**
10:58 47s 519ms	1.4965	1.5074	**1.5020**
10:58 52s 325ms	1.4981	1.5134	**1.5058**
10:58 59s 029ms	1.4968	1.5112	**1.5040**
10:59 00s 119ms	1.4963	1.5152	**1.5058**
10:59 07s 009ms	1.4939	1.5132	**1.5036**
10:59 10s 519ms	1.4978	1.5022	**1.5000**
10:59 19s 259ms	1.4824	1.5153	**1.4989**
10:59 21s 619ms	1.4799	1.5068	**1.4934**
10:59 26s 259ms	1.4879	1.5001	**1.4940**
10:59 32s 951ms	1.4895	1.5078	**1.4987**
10:59 35s 324ms	1.4965	1.5039	**1.5002**
10:59 42s 756ms	1.4922	1.5075	**1.4999**
10:59 49s 999ms	1.4995	1.5065	**1.5030**
10:59 53s 267ms	1.4968	1.5036	**1.5002**
10:59 59s 324ms	1.4958	1.5046	**1.5002**

Step 2: discard illiquid snapshots

Sometimes it is not possible to fill the SMS because there is not enough volume tradeable at that snapshot time. The calculation discards these snapshots.

For our worked example assume that the snapshots at 10:58 31s 005ms and 10:59 07s 009ms did not in fact have enough volume to fill the SMS and therefore couldn't have a VWAMP calculated from them. The calculation now has 22 remaining snapshots to use in step 3.

Check that there are enough liquid snapshots

We then check to see if there are enough liquid snapshots to generate a rate from. If there are 6 or more liquid snapshots then the calculation continues to steps 3 and 4. If not, it tries to generate a rate using movement interpolation (step 5).

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Step 3: discard outlier snapshots

To protect against momentary and unrepresentative spikes in the price, the calculation removes outlying snapshots. To do this, the calculation ranks the snapshots that passed the liquidity checks according to their VWAMPs and any snapshots with a VWAMP greater than the 75th percentile or less than the 25th percentile are removed from the calculation.

In this example, the 25th percentile is 1.498575 and the 75th is 1.501025.

The remaining snapshots are those that have passed the liquidity check and that also have a VWAMP that is between 1.498575 and 1.501025. From our 24 original snapshots, 2 failed the liquidity check, and 11 were excluded by the outlier check, leaving 11 remaining for the final calculation – as shown below:

Snapshot Time	VWB	VWO	VWAMP	Liquidity Check	Outlier Check
10:58 02s 125ms	1.4567	1.5336	**1.4952**	Pass	Fail
10:58 07s 145ms	1.4935	1.5062	**1.4999**	Pass	Pass
10:58 12s 568ms	1.4859	1.5092	**1.4976**	Pass	Fail
10:58 19s 821ms	1.4962	1.5051	**1.5007**	Pass	Pass
10:58 20s 125ms	1.4967	1.5034	**1.5001**	Pass	Pass
10:58 28s 855ms	1.4812	1.5151	**1.4982**	Pass	Fail
10:58 31s 005ms	1.4967	1.5028	**1.4998**	Fail	N/A
10:59 38s 599ms	1.4989	1.5005	**1.4997**	Pass	Pass
10:58 44s 525ms	1.4922	1.5092	**1.5007**	Pass	Pass
10:58 47s 519ms	1.4965	1.5074	**1.5020**	Pass	Fail
10:58 52s 325ms	1.4981	1.5134	**1.5058**	Pass	Fail
10:58 59s 029ms	1.4968	1.5112	**1.5040**	Pass	Fail
10:59 00s 119ms	1.4963	1.5152	**1.5058**	Pass	Fail
10:59 07s 009ms	1.4939	1.5132	**1.5036**	Fail	N/A
10:59 10s 519ms	1.4978	1.5022	**1.5000**	Pass	Pass
10:59 19s 259ms	1.4824	1.5153	**1.4989**	Pass	Pass
10:59 21s 619ms	1.4799	1.5068	**1.4934**	Pass	Fail
10:59 26s 259ms	1.4879	1.5001	**1.4940**	Pass	Fail
10:59 32s 951ms	1.4895	1.5078	**1.4987**	Pass	Fail
10:59 35s 324ms	1.4965	1.5039	**1.5002**	Pass	Pass
10:59 42s 756ms	1.4922	1.5075	**1.4999**	Pass	Pass
10:59 49s 999ms	1.4995	1.5065	**1.5030**	Pass	Fail
10:59 53s 267ms	1.4968	1.5036	**1.5002**	Pass	Pass
10:59 59s 324ms	1.4958	1.5046	**1.5002**	Pass	Pass

Step 4: quality-weight the remaining snapshots to give the ICE Swap Rate:

The ICE Swap Rate is the quality-weighted average of the remaining VWAMPs. Quality is measured for each snapshot by the tightness of the spread between VWB and VWO. A tighter spread means

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that the VWAMP for that snapshot is a more reliable indication of being able to fill standard market size at a price close to that VWAMP.

The calculation combines the remaining VWAMPs using a weighted average with the inverse of the spreads as the weighting factor. In the example, this gives:

Snapshot Time	VWB	VWO	VWAMP	Spread	Weighting
10:58 07s 145ms	1.4935	1.5062	1.4999	0.0127	**5%**
10:58 19s 821ms	1.4962	1.5051	1.5007	0.0089	**6%**
10:58 20s 125ms	1.4967	1.5034	1.5001	0.0067	**9%**
10:59 38s 599ms	1.4989	1.5005	1.4997	0.0016	**36%**
10:58 44s 525ms	1.4922	1.5092	1.5007	0.017	**3%**
10:59 10s 519ms	1.4978	1.5022	1.5	0.0044	**13%**
10:59 19s 259ms	1.4824	1.5153	1.4989	0.0329	**2%**
10:59 35s 324ms	1.4965	1.5039	1.5002	0.0074	**8%**
10:59 42s 756ms	1.4922	1.5075	1.4999	0.0153	**4%**
10:59 53s 267ms	1.4968	1.5036	1.5002	0.0068	**8%**
10:59 59s 324ms	1.4958	1.5046	1.5002	0.0088	**7%**

Summing the weighted VWAMPs gives the final ICE Swap Rate:

- ICE Swap Rate (full granularity) = 1.499988
- ICE Swap Rate (3dp for publication) = 1.500

Step 5: Use movement interpolation

If there were not enough liquid snapshots after step 2 then the calculation will try to use movement interpolation to generate the ICE Swap Rate.

Movement interpolation calculates the ICE Swap Rate for a tenor by adding the interpolated day on day movement to the previous day's rate. The interpolated day on day movement is calculated by averaging the day on day movements of the adjacent tenors on either side of the tenor to be interpolated.

The conditions for using movement interpolation are:

- The tenor to be interpolated must have had a calculated (not interpolated) ICE Swap Rate on the previous business day.
- The previous adjacent tenor must be 1 year shorter than this tenor, and must have had calculated (not interpolated) ICE Swap Rates on both the previous and the current business day.
- The next adjacent tenor must be 1 year longer than this tenor, and must have had calculated (not interpolated) ICE Swap Rates on both the previous and the current business day.

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If these conditions are met, then the ICE Swap Rate for the tenor to be interpolated is calculated using the following formula:

$$X_T = X_{T-1} + \frac{(P_T - P_{T-1}) + (N_T - N_{T-1})}{2}$$

Where

- X is the rate for the tenor to be interpolated
- P is the rate for the previous adjacent tenor
- N is the rate for the next adjacent tenor
- T is the business day for which rate is being calculated
- T-1 is the previous business day for the tenor.

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Special Cases

If the minimum number of liquid snapshots or the conditions for movement interpolation aren't met

If the minimum number of liquid snapshots or the conditions for movement interpolation isn't met then we will publish a 'No Publication' for that tenor.

Crossed Order Books

Because our synthetic order book takes prices from multiple trading venues, it is possible to have a situation where the bid prices in the order book are higher than the offer prices

Synthetic Order Book		
Bid Volume (m)	Price	Offer Volume (m)
	1.5660	19
	1.5630	49
	1.5480	17
30	1.5400	30
	1.5260	
	…	
32	1.4590	30
16	1.4530	
19	1.4500	
35	1.4490	
32	1.4360	

Crossed Orders

In this situation, a trading counterparty could perform risk-free arbitrage by simultaneously buying thirty million at 1.4590 and selling at 1.5400. Executing this trade would remove the crossed book and leave the 'normal' prices remaining.

This scenario is unlikely to occur very often, and if it did, the market would quickly correct itself – so the crossed order book should only exist momentarily and would not be truly representative of the market during the data collection window.

Therefore the calculation checks for and excludes any crossed order books before discarding the outlier snapshots. This removes the crossed order book from the process and the calculation continues as normal.

The minimum number of snapshots is checked against snapshots that are liquid and have not been excluded for crossed order books or zero spread order books (see below).

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Zero Spread Order Books

Similar to the crossed order book case, it is possible for an order book to have a best bid and best offer which are equal to each other.

Synthetic Order Book (Situation 2)		
Bid Volume (m)	Price	Offer Volume (m)
	1.5660	19
	1.5630	49
	1.5480	17
	1.5400	30
65	1.5260	70
	…	
32	1.4590	
16	1.4530	
19	1.4500	
35	1.4490	
32	1.4360	

Orders at the same price

This situation would also be excluded for similar reasons to the crossed order book – we would expect the buyers and sellers to trade with each other at this price and therefore for this situation to only exist momentarily. The calculation excludes these snapshots in the same way as we exclude any snapshots with a crossed order book.

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Appendix 1 – Standard Market Sizes

The Standard Market Sizes for each tenor in each run are (numbers in millions):

Tenor	EUR Rates 1100	EUR Rates 1200	GBP Rates 1100	USD Rates 1100	USD Spreads 1100	USD Rates 1500
1 Year	150	150	25	150	-	150
2 Years	125	125	50	150	150	-
3 Years	100	100	50	150	150	-
4 Years	100	100	30	100	-	-
5 Years	75	75	25	100	100	-
6 Years	60	60	25	75	-	-
7 Years	50	50	20	75	75	-
8 Years	50	50	15	50	-	-
9 Years	40	40	15	50	-	-
10 Years	40	40	15	50	50	-
12 Years	40	40	10	-	-	-
15 Years	30	30	10	40	-	-
20 Years	25	25	10	40	-	-
25 Years	25	25	10	-	-	-
30 Years	20	20	10	25	-	-

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