EUREX

White Paper

Eurex Herfindahl-Hirschman Index for EOBI

Classification	unrestricted
SW-Rel. No.	
Doc.-Ref. No.	
Version	
Date	25.11.2022

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Motivation

For Eurex, transparency is key for fair and orderly trading in a fully electronic and fast-paced financial market environment. At the heart of this trading infrastructure lies the Central Limit Order Book (in the following referred to as order book) as the primary source of firm and competitive liquidity; continuously available, transparent to all market participants, and a reference to many downstream liquidity pools and execution channels. To keep the order book strong and resilient, the participation of a diverse market participant base is needed, following different investment interests via a variety of trading strategies, which eventually result in different liquidity needs at different points in time. For Eurex, this is a key corner stone for a healthy market with competitive prices that are available to all market participants. To achieve these goals, it is the responsibility of the exchanges and the regulators to establish sound and transparent rules that are grounded in sophisticated functionalities to allow all participants to interact in a fair and orderly manner in the same order book.

Eurex is continuously working to shed more light on the market microstructures of its Futures and Options order books and to increase market transparency via additional market data information and tools. With the Eurex Release 11.0 launched on 21. November 2022, a new feature will be made available that will support trading participants to determine the level of market diversification within a product's order book in real-time. Eurex will become the first exchange providing a real-time data feed on the concentration of the passive side of trades and a pre-determined number of price levels within the order book. With this feature, Eurex strives to empower the trading community to be able to evaluate order book concentration, to identify chances and opportunities, and to contribute to liquidity formation and price discovery. For this, Eurex Herfindahl-Hirschman Index for EOBI was developed.

The new feature builds on a vast and rich academic literature of the Herfindahl-Hirschman Index (HHI) applied in macroeconomic as well as microeconomic studies over the last decades and is found to be the standard way of measuring market concentration today. Eurex builds upon this sound academic world by integrating this measure into its high-speed market data feed Enhanced Order Book Interface (EOBI). Within this white paper, Eurex wants to provide insight into this new feature by highlighting the specific setup and implementation used as well as the respective statistical properties that can be inferred from it. Also, a case study is presented that shows and explains the market microstructure dynamics of the Herfindahl-Hirschman Index during the time of the tick sizes increase in the Euro Stoxx 50 Futures product and its implications.

1. **General Observations of HHI in Eurex Markets**

Eurex created a synthetic production like dataset covering the first quarter of 2022 for a set of liquid futures products[1]. These futures products are also in scope for the initial activation of the HHI in the T7 trading system. The below table 1 shows descriptive statistics regarding the distribution of the orderbook HHI per price level for individual futures products (averaged for the bid and ask side). The shown percentages of the HHI indicator are the upper limits of the ordinal HHI groups.

[1] Detail on the calculation of the HHI can be found in Appendix B.

	HHI	Level 1		Level 2		Level 3		Level 4		Level 5	
	Indicator	Count	Time weighted	Count	Time weighted	Count	Time weighted	Count	Time weighted	Count	Time weighted
	20%	70.5%	68.2%	95.9%	91.5%	96.5%	85.2%	97.1%	89.7%	97.6%	91.7%
	40%	21.1%	22.9%	3.7%	7.2%	3.3%	13.7%	2.7%	9.3%	2.3%	7.4%
FESX	60%	8.4%	8.9%	0.4%	1.3%	0.2%	1.1%	0.2%	1.0%	0.2%	0.9%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	68.2%	43.3%	94.1%	60.1%	95.1%	60.9%	95.0%	60.2%	94.5%	59.9%
	40%	22.9%	26.6%	5.0%	12.3%	4.0%	10.1%	4.2%	10.8%	4.7%	10.3%
FESB	60%	8.9%	30.1%	0.9%	27.7%	0.8%	29.0%	0.8%	29.0%	0.8%	29.8%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	65.2%	44.0%	91.1%	57.0%	93.9%	57.9%	94.4%	58.2%	94.6%	58.4%
	40%	25.3%	32.3%	8.3%	11.1%	5.4%	9.2%	4.9%	9.0%	4.6%	9.2%
FXXP	60%	9.5%	23.7%	0.7%	31.9%	0.7%	32.9%	0.7%	32.8%	0.8%	32.4%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	49.1%	49.2%	83.2%	74.5%	91.6%	80.9%	94.3%	82.3%	95.0%	82.7%
	40%	28.0%	29.7%	13.0%	15.1%	6.1%	9.8%	3.8%	8.9%	3.3%	8.7%
FDAX	60%	22.9%	21.1%	3.8%	10.5%	2.3%	9.4%	1.9%	8.8%	1.7%	8.6%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	24.8%	25.8%	68.1%	63.9%	88.3%	75.6%	91.6%	79.6%	92.7%	81.7%
	40%	37.6%	41.3%	27.0%	28.8%	9.9%	18.4%	7.0%	14.7%	6.0%	13.1%
FDXM	60%	37.6%	32.9%	4.9%	7.3%	1.8%	6.0%	1.4%	5.7%	1.3%	5.2%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	74.1%	71.7%	97.4%	94.6%	98.0%	94.5%	98.3%	96.5%	98.4%	97.1%
	40%	18.4%	20.8%	2.4%	5.1%	1.9%	5.4%	1.6%	3.3%	1.5%	2.7%
FGBL	60%	7.5%	7.5%	0.1%	0.2%	0.1%	0.2%	0.1%	0.2%	0.1%	0.1%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	76.2%	75.4%	98.3%	96.6%	98.4%	95.1%	98.5%	95.9%	98.5%	97.3%
	40%	17.1%	18.8%	1.7%	3.2%	1.6%	4.8%	1.5%	4.0%	1.4%	2.5%
FGBM	60%	6.6%	5.7%	0.1%	0.2%	0.0%	0.1%	0.0%	0.1%	0.0%	0.2%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	71.6%	62.6%	95.2%	85.7%	95.7%	88.4%	95.8%	88.8%	95.4%	87.7%
	40%	19.5%	27.2%	4.3%	12.3%	4.0%	10.2%	3.9%	10.0%	4.2%	10.9%
FGBS	60%	8.9%	10.2%	0.5%	2.0%	0.4%	1.4%	0.3%	1.2%	0.4%	1.4%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	66.4%	56.4%	95.6%	83.8%	96.6%	81.1%	96.5%	80.0%	96.7%	84.5%
	40%	20.0%	24.0%	3.7%	12.4%	2.9%	15.7%	2.9%	16.2%	2.7%	11.6%
FGBX	60%	13.6%	19.6%	0.7%	3.8%	0.5%	3.2%	0.6%	3.8%	0.6%	3.9%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	74.2%	57.5%	96.4%	73.0%	97.0%	79.4%	97.3%	81.1%	97.5%	82.5%
	40%	17.8%	28.3%	3.2%	22.9%	2.6%	15.9%	2.3%	13.9%	2.1%	12.8%
FOAT	60%	8.0%	14.2%	0.4%	4.1%	0.4%	4.7%	0.4%	5.1%	0.4%	4.8%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	74.5%	79.2%	94.7%	94.4%	94.2%	93.6%	94.5%	93.7%	94.5%	93.5%
	40%	18.6%	16.0%	5.0%	5.2%	5.4%	6.0%	5.2%	5.9%	5.2%	6.0%
FBTS	60%	6.9%	4.8%	0.3%	0.4%	0.3%	0.4%	0.3%	0.4%	0.3%	0.4%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	20%	64.2%	66.0%	93.8%	93.5%	96.2%	95.9%	96.6%	96.2%	96.8%	96.4%
	40%	22.2%	22.9%	5.7%	5.8%	3.5%	3.7%	3.1%	3.4%	3.0%	3.2%
FBTP	60%	13.6%	11.1%	0.5%	0.6%	0.3%	0.4%	0.2%	0.4%	0.2%	0.4%
	80%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 1: Distribution of observations respective time of given HHI observations for the best five price levels during Q1/2022.

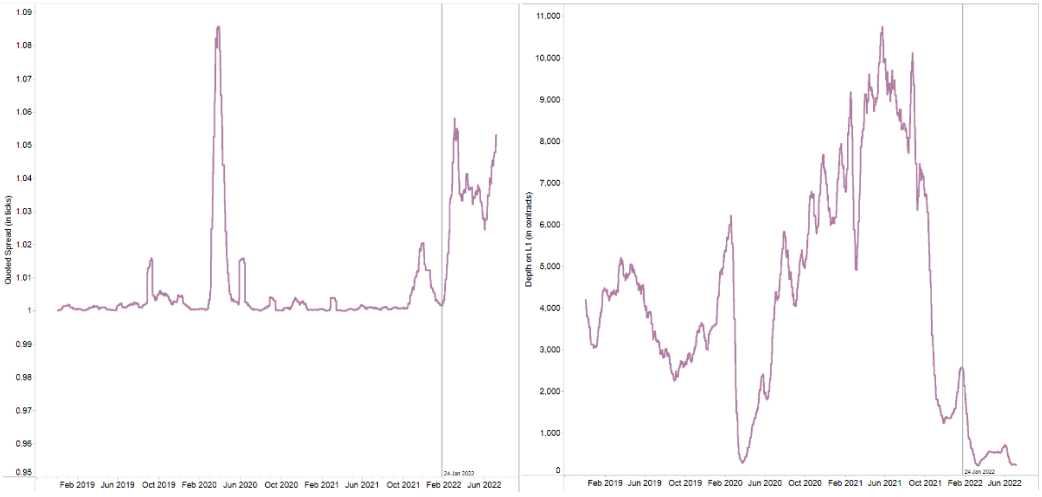
First, simple counting (especially on the best price level), will give more weight (relative to time-weighted counting) to orderbook states with a shorter lifetime, which is the case with higher Herfindahl levels. This is partially driven by the first order on a newly created best price level (which has then by definition a HHI of 100%). Typically, other participants follow the first order, within a very short time interval. As it can be seen in table 1, using time-weighted averages, instead of simple averages, will account for this phenomenon by resulting into smaller HHI values compared to simple counting.

Second, it seems that products with a more stable price picture will have more competitive orderbooks, indicated by lower Herfindahl levels. For example, the FGBL, has 71.1% of the timeweighted observation on the best price level in the lowest HHI bucket, while the corresponding number for the FGBM is 75.4% and for the FGBS is 62.6%. As FGBS, has a smaller ticksize compared to the other two products, one should rather use the second price level for comparison, which has a HHI of 85.7%. This can potentially be explained by the difference in the modified duration of the underlying bonds, which is highest for FGBL, and lowest for FGBS, while FGBM is in between.

And third, the deeper price levels have a more diverse liquidity picture compared to the best price level. This can potentially be explained by a) more passive participants are able to provide liquidity beyond the best price level and b) specialized participants have orders in the orderbook at deeper price levels to preserve time-priority once these price levels get more relevant.

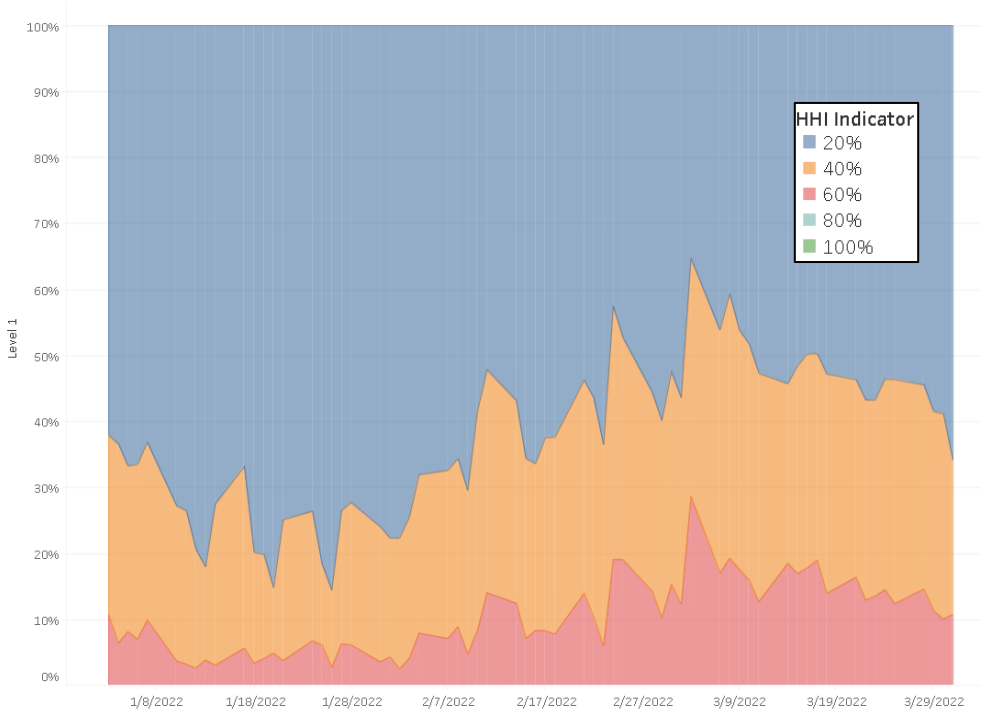
Further factors that influence the distribution of the HHI are changes in product characteristics and market characteristics. The impact of changes in product characteristics are discussed in detail in section 2.1, based on the example of the tick size change in the FESX during March 2022 which was also impacted by the Russian invasion of Ukraine. The impact of changing market characteristics is discussed below, based on the example of the increasing levels of interest rates as well as significant increase of the volatility of the derived sovereign futures.

Below Graph 1 shows the top of book liquidity of the FGBS front month contract during European Trading Hours (9:00 – 17:30 CET). The quoted spread is close to one tick over the last years, with outliers during the Covid-19 turmoil in March 2020 and since mid-February 2022 due to the Russian invasion of Ukraine. The picture for the size on the best price level is more volatile. Especially in 2022, we can see a massive reduction which is potentially driven by significant increase of realized volatility, which has evolved from around 0.5% in 2021 to around 4% starting end of January 2022. These changes are most likely driven by exogeneous factors such as inflation and rising interest rates.



Graph 1: Time Series of the quoted spread as well as the available liquidity on the BBO for FGBS for Q1/2022. For every trading day the graph shows the average quoted spread respectively the average number of contracts on the best price level during European trading hours (09:00 – 17:30 CET) for the front month contract. To reduce the noise in the data, we applied local averages for each daily value by taking the average of the previous and following five days.

Graph 2 shows the impact of changing market characteristics in the FGBS during the first quarter of 2022 on the distribution of the HHI. The values shown are the daily time-weighted distribution of the HHI Indicator values on the best price level in the front month contract. During the rather stable period the product showed a high diversification with only 5% of the time in the third HHI bin (between 40% and 60%). However, this changed once the volatility end of January increased and the liquidity in the product became more concentrated to fewer participants. One reason is that the risk for passive participants increases once the market becomes more volatile, and therefore less participants can bear that risk.



Graph 2: Time Series HHI plot for FGBS for Q1/2022. For every trading day the graph shows the relative distribution of HHI indicator flagged in the EOBI market data on a time-weighted basis of the best bid and offer price level in the front-month contract (Level 1). Colors indicate the respective HHI bucket with the relative appearance over each trading day.

2. Insights into HHI - Market Microstructure Observations

2.1. Case Study FESX Tick size

Background:

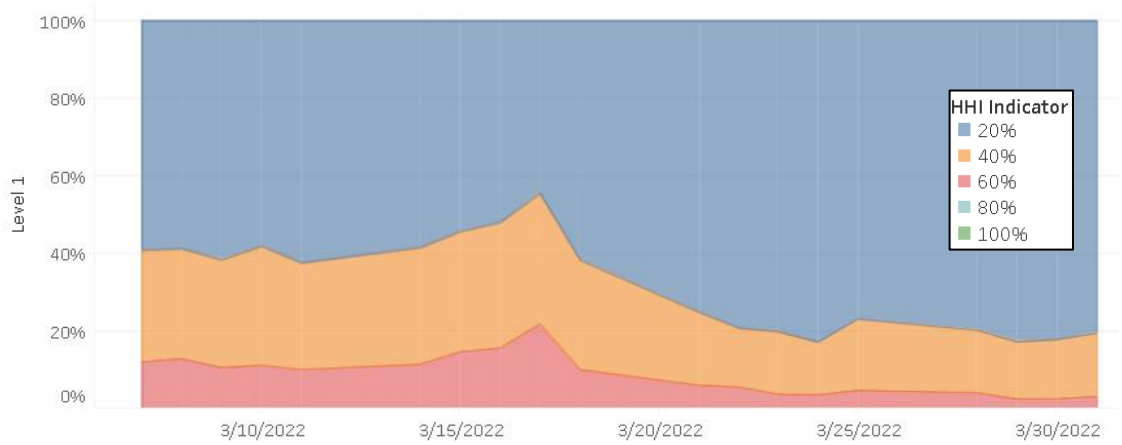
With effect from 21 March 2022, Eurex increased the minimum price change (tick) in outright contracts in EURO STOXX® 50 Index Futures (FESX), one of the most liquid benchmark future products at Eurex. The new tick was determined to be 1.0 index points after having it reduced from 1.0 to 0.5 index points in June 2021.

Prior to June 2021 with a valid tick size of 1.0, most of the time during the trading day the observed bid-ask spread is equal to smallest possible value of one tick. Hence, market participants cannot provide more competitive prices without crossing the bid-ask spread. Thus, the decrease in the tick size after June 2021 opened a new price level available for passive liquidity providers to quote more aggressively than before. Consequently, the increase in the tick size after March 2022 removed this additional price level, which provides the interesting opportunity to evaluate the respective level of concentration during this time applying the HHI information feed.

Time Series Observations:

Eurex Trading Design conducted time series monitoring to capture this very interesting market microstructure change to evaluate the quality and competitiveness of liquidity provision during this time. Therefore, the HHI has been applied to observe changes in the liquidity provision activity when increasing the tick size from 0.5 to 1.0 tick. However, it must be clearly mentioned that also geopolitical events overshadowed this period, likewise, affecting market dynamics and trading behavior severely. Therefore, for this observation only a very narrow observation period was chosen, i.e., 10 days before and after the event.

The graphs provided in the following are based on the same production-alike setup of the HHI intended for go-live in December 2022. HHI is aggregated into five equidistant buckets, only front month instruments are covered in this evaluation. HHI is observed throughout each trading day and aggregated into a daily distribution where 100% resembles all HHI observations over one specific trading day. Other than treating every observation equally, it is more accurate to take into account the respective amount of time each observation was available to capture the time series dynamic of each trading day. Graph 3 depicts the daily time series observations of all time weighted HHI observations within ten days before and after the tick size change.



Graph 3: Time Series HHI plot for FESX +/- 10 trading days before and after 21 March 2022. For every trading day the graph shows the relative distribution of HHI indicator flagged in the EOBI market data on a time-weighted basis of the best bid and offer price level in the front-month contract (Level 1). Colors indicate the respective HHI bucket with the relative appearance over each trading day.

It is clearly visible that before 21 March 2022, the additional available top price level at 0.5 index points (level 1) had higher concentration levels compared to the period afterwards. On average, between 50% and 60% of all daily time weighted HHI observations show the lowest HHI bucket, i.e., HHIs between 0.0 and 0.2, on level 1. Relative to other products, shown in table 1, this shows a more concentrated liquidity picture on the additional price level. Although not visible in the short observation period, Eurex observed that there are two additional effects that amplify

this effect toward a very high HHI value shortly before the tick size change in March 2022. First, the announcement of the tick size reversal end of January 2022 showed an effect as trading participants subsequently started to prepare for this change and stopped adjusting to the new tick size regime. This was further catalyzed by the geopolitical turbulences in Ukraine starting end of February 2022 with market participants withdrawing on level 1 and concentration growing further given the additional volatility in the market.

With the increase in the tick size after March 2022, the picture changed dramatically. Already in the first few days afterwards, the new top price level at 1.0 tick (new level 1) experienced a sudden increase in diversification among trading participants. Up to 80% of the daily coverage within the first few trading days after the change, the daily time weighted HHI observations showed a very high level of participant competition indicated by the lowest HHI bucket, i.e., HHIs between 0.0 and 0.2. The amount of time per day where level 1 experienced a medium level of concentration (e.g., HHI between 40% and 60%) is significantly reduced, indicating healthier competition on the best price level. Keeping in mind that not all market participants changed their behavior on the first 10 trading days, but prefer to wait longer to adjust their behavior, this is a remarkable result, especially despite the remaining high level of volatility in the market.

2.2. Potential further Use Case for HHI

Within the second use case, Eurex wants to provide some ideas on how to potentially roll out HHI into further academic or practical considerations worth evaluating. In the following there are some examples for applying HHI as an alternative or complementary measure for typical market microstructure issues:

- There is already a vast literature examining the behavior of bid-ask spread reaction towards return dynamics and time variation of liquidity. The key question is, how does the price impact of a trade influence spread stability and predict new price levels. When considering the imbalance of the order book as a possible determinant, which is common in many studies, prior to the transaction, HHI imbalance provides an additional measure for order book imbalances or market maker inventory balance considerations when evaluating the stability of a current price level or predicting price movements.
- Market quality performance indicators such as the market depth which consider the aggregated volumes available in the order book set for a specific to-be-executed volume or price would benefit by incorporating the concentration of the respective price levels to anticipate potential spurious liquidity in case of a high concentration.

Appendix

A) Description of the Data structure

Eurex will provide a synthetic test dataset for Participants to be able to prepare their algorithms based on the new information. The dataset is available via the following link:

https://a7-dataplatform.deutsche-boerse.com/download/1f9b8d39-f01d-45b2-b3b9-e8276b69fb6c

Please note that the data is available until 23 December 2022. The dataset covers the first quarter of 2022 and all products mentioned in the product scope. The dataset contains synthetically created orderbook data as well as synthetically created trade data.

The orderbook data contains every tick during the continuous trading period. The data is separated by product, day, and security ID. For each of these combinations several files are available, which are described in the following Table 2.

Filetype	Description
TD	Contains date, time, reference data
BIDP	Contains the prices for the best 10 price levels on the bid side. Prices are multiplied with 1,000.
BIDS	Contains the sizes for the best 10 price levels on the bid side
HHIBID	Contains the index of the HHI Indicator for the best 10 price levels on the bid side
ASKP	Contains the prices for the best 10 price levels on the ask side. Prices are multiplied with 1,000.
ASKS	Contains the sizes for the best 10 price levels on the ask side
HHIASK	Contains the index of the HHI Indicator for the best 10 price levels on the ask side

Table 2: Description of the various datatypes in the file structure for the orderbook data.

The filename is created with the following logic:

Filename = product id + file type + date + instrument id + ".csv "

The fields in the files with the file type “TD” are described in the following table 3.

Column name	**Description**
Nanos_since_Midnight	Matching engine timestamp (t_7) expressed in nanoseconds since 12:00 am UTC
Year	Year
Month	Month
Day	Day
Hours	Hour of the Matching engine timestamp (t_7) in UTC
Minutes	Minutes of the Matching engine timestamp (t_7) in UTC
Seconds	Seconds of the Matching engine timestamp (t_7) in UTC
Millis	Milliseconds of the Matching engine timestamp (t_7) in UTC
Micros	Microseconds of the Matching engine timestamp (t_7) in UTC
Nanos	Nanoseconds of the Matching engine timestamp (t_7) in UTC
Product_ID	Symbol (e.g. FESX)
Instrument_ID	Security ID (unique contract identifier)
Expiration	Expiration Month (e.g. 202203)

Table 3: Description of the various fields for the file type “TD” for the orderbook data.

The files with the file type BIDP, BIDS, BIDC, HHIBID, ASKP, ASKS, ASKC and HHIASK have columns with column names 0 to 9 indicating the 10 best price levels (with the column name 0 being the best price level).

Nanos_since_Midnight	Year	Month	Day	Hours	Minutes	Seconds	Millis	Micros	Nanos	Product_ID	Instrument_ID	Expiration
901050428787.0	2022	1	3	0	15	1	50	428	787	FESX	5035794	202203
901052104879.0	2022	1	3	0	15	1	52	104	879	FESX	5035794	202203
901052136534.0	2022	1	3	0	15	1	52	136	534	FESX	5035794	202203
901052201287.0	2022	1	3	0	15	1	52	201	287	FESX	5035794	202203
901052208649.0	2022	1	3	0	15	1	52	208	649	FESX	5035794	202203
901052238175.0	2022	1	3	0	15	1	52	238	175	FESX	5035794	202203
901052269829.0	2022	1	3	0	15	1	52	269	829	FESX	5035794	202203
901052278707.0	2022	1	3	0	15	1	52	278	707	FESX	5035794	202203
901052295589.0	2022	1	3	0	15	1	52	295	589	FESX	5035794	202203
901052305657.0	2022	1	3	0	15	1	52	305	657	FESX	5035794	202203
901052314360.0	2022	1	3	0	15	1	52	314	360	FESX	5035794	202203
901052340890.0	2022	1	3	0	15	1	52	340	890	FESX	5035794	202203
901052355470.0	2022	1	3	0	15	1	52	355	470	FESX	5035794	202203
901052374773.0	2022	1	3	0	15	1	52	374	773	FESX	5035794	202203
901052391987.0	2022	1	3	0	15	1	52	391	987	FESX	5035794	202203
901052397648.0	2022	1	3	0	15	1	52	397	648	FESX	5035794	202203
901052416576.0	2022	1	3	0	15	1	52	416	576	FESX	5035794	202203

Graph 4: Screenshot of the first lines of the orderbook data for the filetype "TD" for FESX on 2022-01-03.

The trade data contains every match event during the continuous trading period. The data is separated by product ID and day. For each of these combinations one file is available.

The filename is created with the following logic:

Filename = product id + "_Trd_" + date + ".csv "

with date being in the YYYY-MM-DD format. The fields in the files are described in the following table 4.

Column name	**Description**
FACT_DATE	Date in YYYY-MM-DD format
FACT_TIMESTAMP	Matching engine timestamp (t_7) expressed in YYYY-MM-DD HH:MM:SS.000000 in UTC time
Nanos_since_Midnight	Matching engine timestamp (t_7) expressed in nanoseconds since 12:00 am UTC
Security ID	unique contract identifier
AggressorSide	Side of the aggressive order (1=Buy, 2=Sell)
LastQty	Total quantity executed by the aggressive order
LastPx	Worst price of the execution
TradingHHIIndicator	The trading HHI is the index to the HHI interval of the match event.
Product_Business_ID	Symbol (e.g. FESX)

Table 4: Description of the various fields for the trade data.

FACT_DATE	FACT_TIMESTAMP	Nanos_since_Midnight	Security ID	AggressorSide	LastQty	LastPx	TradingHHIIndicator	Product_Business_ID
2022-01-03 00:00:00.000000	2022-01-03 00:15:00.050977	900050977456	5035794	2	8	4293.5	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:00.058587	900058587180	5035794	2	1	4293.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:00.060746	900060746802	5035794	2	2	4293.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:00.329771	900329771955	5035794	2	1	4293.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:00.331513	900331513589	5035794	2	4	4293.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:00.453321	900453321633	5035794	2	4	4293.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:00.627331	900627331447	5035794	2	4	4293.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:00.627385	900627385002	5035794	2	18	4293.0	1	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:00.627954	900627954963	5035794	2	1	4292.5	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.052136	901052136534	5035794	2	1	4291.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.052208	901052208649	5035794	2	2	4290.5	2	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.052238	901052238175	5035794	2	1	4290.5	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.052340	901052340890	5035794	2	1	4290.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.052355	901052355470	5035794	2	1	4290.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.052442	901052442908	5035794	1	1	4290.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.078647	901078647108	5035794	1	3	4289.5	2	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.533382	901533382829	5035794	2	1	4288.5	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.533517	901533517880	5035794	1	1	4289.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.579712	901579712597	5035794	2	1	4288.5	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.580723	901580723601	5035794	2	3	4288.5	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.580904	901580904300	5035794	1	1	4288.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.580992	901580992120	5035794	2	1	4287.0	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.581019	901581019826	5035794	1	1	4287.5	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.581133	901581133258	5035794	1	2	4287.5	4	FESX
2022-01-03 00:00:00.000000	2022-01-03 00:15:01.581151	901581151574	5035794	1	6	4287.5	4	FESX

Graph 5: Screenshot of the first lines of the trade data for FESX on 2022-01-03.

B) HHI Definition and Properties

The HHI, independent whether it is the *orderbook HHI*, or the passive *trading HHI*, is calculated as the sum of squared market shares,

$$HHI = \sum_i s_i^2,$$

with i being an index for the business unit and s_i being the respective market share of business unit i. The HHI is defined between zero and one. A HHI of one happens if one participant is active with a market share of 100% (no competition), while an HHI of zero can happen if an infinitesimal large number of participants with equal market share are active (perfect competition).

The **market share** for the ***orderbook HHI*** for a specific price level j on one side of the orderbook is defined as:

$$HHI^{(j)} = \sum_i \left(s_i^{(j)}\right)^2 \quad with \quad s_i^{(j)} = \frac{q_{ij}^{bk}}{\sum_i q_{ij}^{bk}}$$

where q_{ij}^{bk} is the accumulated quantity of the order quantities of business unit i per price level j per orderbook side.

The **market share** for the ***trading HHI*** is defined as:

$$HHI = \sum_i s_i^2 \quad with \quad s_i = \frac{\sum_j q_{ij}^{trd}}{\sum_{i'} \sum_j q_{i'j}^{trd}}$$

where q_{ij}^{trd} is the traded quantity of the outright orders of business unit i per match step j on the passive side of the orderbook and i' denotes that the trading quantities of all participating business units involved in the match event are considered.

Note that the whole trading quantity of business unit i is considered in the calculation of the *trading HHI*. Introducing the index j is to emphasize that there might be several match steps (matching cascade) with a dedicated $MatchPrice_j$ comprising a match event.

The publication of the HHI is referring to specific HHI intervals. The upper interval limits for the ordinal HHI scale will be set up as shown in table 5.

Upper Interval limit	Index
0.2	0
0.4	1
0.6	2
0.8	3
1.0	4

Table 5: Upper interval limits for the ordinal scale for the HHI Indicator.

These parameters are applicable for all products for which the HHI will be activated. The HHI intervals are disseminated via the T7 RDI/RDF reference data interface.

Initially, the publication of the HHI is limited to liquid futures according to table 6 .

Product ID	Product Name
FESX	EURO STOXX 50® Index Futures
FDAX	DAX® Futures
FDXM	Mini-DAX® Futures
FESB	EURO STOXX® Banks Futures
FXXP	STOXX® Europe 600 Index Futures
FGBL	Euro-Bund Futures
FGBM	Euro-Bobl Futures
FGBS	Euro-Schatz Futures
FGBX	Euro-Buxl® Futures
FOAT	Euro-OAT Futures
FBTP	Long-Term Euro-BTP Futures
FBTS	Short-Term Euro-BTP Futures

Table 6: Product list in scope for sequential activation of the HHI.