

A Practical Guide to 10-level Order Book Historical Data [English Translation]

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This document serves as the definitive English reference for the **10-level Order Book Historical Dataset** hosted on the Snowflake platform. It provides the technical framework, data dictionary, and analytical methodologies required to leverage this high-granularity market data for quantitative research, execution analysis, and compliance monitoring.

<Disclaimer>

Use of Information

The information contained in this guide is provided for the purpose of helping users understand the specifications of the 10-level order book historical dataset. While JPX Market Innovation & Research, Inc. (JPXI) strives to ensure the accuracy of the content, the information is provided for reference purposes only. Users should always consult the formal technical data specifications for the most current and precise system details.

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1. Introduction

Historically, quantitative researchers analyzing the market data of Tokyo Stock Exchange (TSE) were required to process raw "FLEX" protocol messages—a differential, non-snapshot message stream—to reconstruct the state of the order book. This process imposed a significant data engineering burden, requiring complex state-management logic to handle sequence numbers and message-based book building.

The 10-level order book dataset represents a strategic shift from differential messages to a "Snapshot" architecture. In this dataset, every record represents a complete, time-stamped state of the order book. This transition provides three primary benefits:

1. **Reduced Data Engineering Overhead:** Users no longer need to build and maintain manual book reconstruction engines. The burden of state-tracking is removed.
2. **High-Granularity Access:** The data provides 10 levels of price/quantity depth, aggregate "OVER (ask quotes above 10th level) and UNDER (bid quotes below 10th level)" liquidity, and aggregate market order volume, offering a view covering often uncovered information such as “quote flag.”
3. **Snowflake-Native Accessibility:** Unlike sequential message parsing which requires local compute resources, this dataset is optimized for analytical SQL queries. Hosting on Snowflake allows for immediate, horizontally scalable joins and filters across years of historical state records.

2. Key Data Items Included

The dataset is primarily delivered through the `TSE_FLEX_ITA_REAL` view. Please refer to the **Connectivity Specifications 10-level Order Book Historical Data** for the details of the field specifications.

Field Name	Snowflake Column	Description
Date	DATE	Record generation date.
Time	TIME	Record generation time (Microsecond granularity).
Update Number	UPDATE_NUM	A unique, monotonically increasing sequencer assigned to each record for each stock. The only definitive primary key for chronological state reconstruction. Date, Issue Code (ticker), and Update Number are the primary keys to identify a record.
Trading Volume (Cumulative)	ACCUM_VOLUME	Total volume traded for the business day.

Trading Volume (for Each Trade)	VOLUME	Volume of the specific execution event.
Turnover (Cumulative)	ACCUM_VALUE	Total turnover (value) for the business day.
Turnover (for Each Trade)	VALUE	Turnover of the specific execution event.
Quotes Q1–Q10	(example) Q1_ASK_PRICE, Q1_ASK_QUANTITY	Price and Quantity for 10 priority levels (Ask/Bid).
OVER/UNDER	QO_OVER_QUANTITY, QO_UNDER_QUANTITY	Cumulative quantity beyond the 10th level.
Market Orders	QM_ASK_QUANTITY, QM_BID_QUANTITY	Aggregate market order volume (Auction phases).

2.1. How to Read Quote Information

First, we will explain using simple order book information during continuous trading (Zaraba) as an example. For simplicity of explanation, some items have been omitted**

	Ask	Price	Bid	
QO →	80	OVER		
Q10 →	10	220		
		⋮		
Q2 →	20	208		
Q1 →	100	206		
		205		
		203	50	← Q1
		202	150	← Q2
		⋮		
		190	5	← Q10
		UNDER	30	← QO

The quote information representing this order book state fundamentally consists of 11 types: Q1, Q2, Q3, ... Q9, Q10, and QO (meaning Over). The number following 'Q' indicates quote information moving outward from the 1st level, which represents the lowest ask (Best Ask) and highest bid (Best Bid), respectively. There are 10 levels from 1 to 10, and the quote quantities

further outside these levels are aggregated under the tag 'QO'. (Information on market orders represented by 'QM' is used during the Itayose [call auction] state, so it is omitted here.)

(Quote Information Image in the 10-level Order Book Dataset)

	Ask		Bid	
	Price	Quantity	Price	Quantity
Q1	206	100	203	50
Q2	208	20	202	150
:	:	:	:	:
Q10	220	10	190	5
QO	-	80	-	30

In this dataset, each record represents the order book state at that point in time. For example, if values are populated from Q1 through Q8, while Q9, Q10, and QO contain no values, it indicates that the order book had quotes displayed across eight price levels at that time.

2.2. How to Determine the Sequence of Quote Transitions

Please refer to the Update Number to determine the order in which information occurs for each stock. While the transition sequence can generally be understood from the timestamp information, the possibility of multiple quote changes occurring at the exact same timestamp is not zero; therefore, it is necessary to track the sequence of transitions based on the Update Number.

3. Liquidity Metrics & Analytical Methods

3.1. BBO Metrics

(Example)

Q1_ASK				Q1_BID			
Price	Time	Quote Flag	Quantity	Price	Time	Quote Flag	Quantity

206	13:50:12.123456	1	100	203	13:50:12.123456	1	50
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Since ask quotes and bid quotes are recorded in pairs, the prices for Q1 Ask and Q1 Bid constitute the Best Bid and Offer (BBO). Therefore, by referring to Q1 Ask and Q1 Bid, metrics such as the BBO Mid-Price, BBO Spread, and Half-Spread can be easily calculated.

- **BBO Mid-price:** $(Q1_ASK_PRICE + Q1_BID_PRICE) / 2 = 204.5$
- **BBO Spread:** $(Q1_ASK_PRICE - Q1_BID_PRICE) / \text{BBO Mid-price} = 1.456 \text{ bps}$
- **Half-Spread:** $\text{BBO Spread} / 2 = 0.733\text{bps}$

3.2. Depth Calculation

(Example)

Q1_ASK				Q1_BID			
Price	Time	Quote Flag	Quantity	Price	Time	Quote Flag	Quantity
206	13:50:12.123456	1	100	203	13:50:12.123456	1	50

When executing orders, liquidity is just as important as price. While trading volume and turnover are standard indicators of liquidity, another key representative metric is 'depth' (order book depth). Depth at the best quote (BBO depth) is most used, which corresponds to 'Q1 Ask Quote Quantity' and 'Q1 Bid Quote Quantity'.

If you wish to examine the order book depth beyond the best quotes, summing the quantities across quote levels—such as $Q1 + Q2 + Q3 + \dots$ —allows you to evaluate the cumulative liquidity that can be absorbed up to a given price level.

(Order Book Example)

Accumulated Volume	Ask Quantity	Price	Bid Quantity	Accumulated Volume
	80	OVER		
⋮		⋮		⋮
(Q1+Q2+Q3+Q4) 160	10	210		
(Q1+Q2+Q3) 150	30	209		
(Q1+Q2)120	20	208		
(Q1)100	100	206		
		205		
		203	50	50
		202	150	200
		201	80	280
		200	30	310
⋮		⋮		⋮
		UNDER	30	

3.3. Trade Execution Tracking

This dataset contains a large number of records consisting solely of quote updates without trade executions reflecting quote updates not accompanying any execution. A simple method to filter for trade execution data from this dataset is to extract records where values are populated in 'Trading Volume (for Each Trade)' and 'Turnover (for Each Trade)', which represent the trading volume and turnover executed for that specific trade upon execution.

When checking the accumulation of trading volume and turnover, 'Trading Volume' and 'Turnover', which represent all-day cumulative values, are convenient to use.

3.4. VWAP (All-Day)

VWAP is also a widely used indicator, and 'VWAP' field indicates the all-day VWAP. Because the all-Day VWAP is updated upon each trade execution, determining the final all-Day VWAP requires identifying when trading for the day has closed.

The close of trading can be determined with 'ISSUE_STATUS' field. An Issue Status of 40 indicates that trading has ended. Furthermore, 'SESSION' field allows you to distinguish between the morning and afternoon sessions, making it straightforward to retrieve the VWAP at the end of the morning session and at the close of trading.

Session	Change Flag	Issue Status	Status Flag	Time
01 : Morning	1	40 :立会終了	A0 : Trading Halt (Accepting Order Input)	Morning Session Close Time
02 : Afternoon	1	40 :立会終了	Space : Other than the above	Afternoon Session Close Time

3.4. VWAP (For a Specific Time Window)

Calculating intraday time-window VWAP can be easily accomplished using 'ACCUM_VOLUME' field (cumulative trading volume)' and 'ACCUM_VALUE' field (cumulative Turnover)'.

(Example) VWAP from 13:00 to 14:00

Step 1: Obtain the cumulative trading volume and cumulative turnover prior to the target time window.

MAX(ACCUM_VOLUME) and MAX(ACCUM_VALUE)
where TIME is earlier than 13:00

	UPDATE_NUM	ACCUM_VOLUME	TIME	ACCUM_VALUE	TIME
Last Trade	11250	501500	1259	55165000	1259
	11255	501600	1300	55277000	1300

Step 2: Obtain the last cumulative trading volume and cumulative turnover within the time window

MAX(ACCUM_VOLUME) and MAX(ACCUM_VALUE)
where TIME is equal or later than 13:00 and earlier than 14:00

	UPDATE_NUM	ACCUM_VOLUME	TIME	ACCUM_VALUE	TIME
Last Trade	12089	577000	1359	63731500	1359
	12092	577400	1400	63767100	1400

Step 3: Calculated using the following formula:

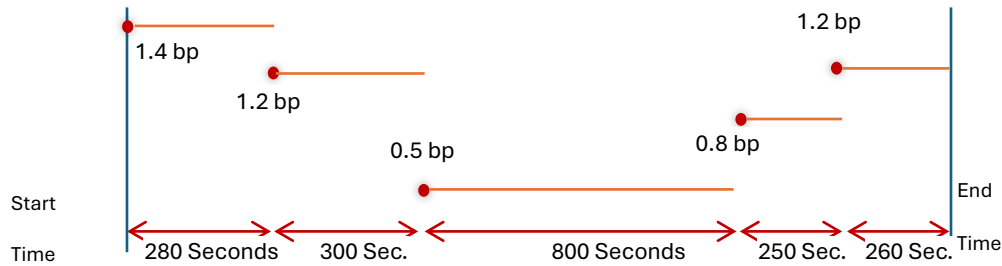
$$\begin{aligned} & (\text{ACCUM_VALUE in Step 2} - \text{ACCUM_VALUE in Step 1}) \\ & \div (\text{ACCUM_VOLUME in Step 2} - \text{ACCUM_VOLUME in Step 1}) \\ & = (63,731,500 - 55,165,000) \div (577,000 - 501,500) \\ & = 113.46358 \end{aligned}$$

In addition to the method using cumulative trading volume and cumulative turnover described above, intraday time-window VWAP can also be calculated using trading volume and value for each trade.

3.6. Daily Statistics and Time-Weighted Averages

While this dataset is rich in detail, a single issue can generate several million records per day, which may represent too fine a granularity for analyzing the market as a whole. When making cross-sectional comparisons of BBO Spread levels across different issues, a simple method is to compare the simple arithmetic averages of the individual BBO Spreads calculated using the previously mentioned methods.

For highly liquid issues, this simple method works sufficiently well; however, for less liquid issues, quote updates occur less frequently, making it more accurate to weight each quote by the time duration it remained exposed to the market. Below is an example comparing calculations using a time-weighted average versus a simple average. Because the duration with a 0.5 bp BBO Spread is long, the time-weighted average feels closer to actual market conditions; however, because this calculation involves a significant computational load, please choose the appropriate method depending on the liquidity of the target issue and your analytical objectives.



Simple Average $(1.4+1.2+0.5+0.8+1.2)/5 = \mathbf{1.02 \text{ bp}}$

Time-Weighted Average $\frac{(1.4 \times 280 + 1.2 \times 300 + 0.5 \times 800 + 0.8 \times 250 + 1.2 \times 260)}{(280+300+800+250+260)} = \mathbf{0.88 \text{ bp}}$

The 'Time-Weighted Average Depth' is also used as part of daily statistics. Because it serves as an indicator of the average quantity present on the order book, a time-weighted average is closer to actual market conditions; however, as it similarly requires significant computational effort, you should select the appropriate method depending on your analytical objectives.

When calculating daily statistics, please keep the following points in mind:

- The timestamp information used to calculate time-weighted averages is stored in the database in the HHMMSSttttttt format. When calculating time differences, please convert the sexagesimal (base-60) hours and minutes into seconds to align everything into a decimal (base-10) format prior to computation.
- Quotes continue to update outside trading hours (such as during order acceptance periods before the market opens); however, because no trade executions take place during these times, order book behavior differs from that during active trading hours. Excluding non-trading hours from your calculations will yield statistical values that reflect actual market conditions more accurately. This is an important consideration whether you are using a time-weighted average or a simple average.

3.7. Intraday Market Statistics

Generally, trading volume is said to tend to increase at the opening and closing of trading sessions during the day. Overseas markets are said to exhibit a V-shaped volume curve, whereas in Japan, because trading is split into morning and afternoon sessions, the volume curve draws a W-shape—effectively two Vs. For instance, when designing execution strategies targeting VWAP, historical volume curves are often taken into consideration, making intraday market statistics essential. Other market statistics such as BBO Spreads and order book depth may also display distinct intraday patterns, and examining metrics beyond trading volume on a time-window basis can lead to insightful discoveries.

By aggregating the information in this dataset across various time intervals, you can calculate intraday market statistics tailored to your specific analytical objectives.

3.8. Quotes at the Opening Auction and Closing Auction

The primary difference between quotes during Zaraba (continuous trading) and the order acceptance periods prior to the opening and closing auctions is the occurrence of a crossed order book state—a state where executable orders exist on the book but are awaiting the session opening time.

ACCUM. VOLUME	ASK VOLUME	PRICE	BID VOLUME	ACCUM. VOLUME
	4,200	MARKET ORDER	5,300	
	3,200	OVER		
⋮		⋮		⋮
7,900	2,000	540		5,300
5,900	500	539	300	5,600
5,400	800	538	1,000	6,600
4,600	100	536		6,600
4,500		535		6,600
4,500	200	533	500	7,100
4,300	100	532	300	7,400
4,200		531	800	8,200
4,200		530	300	8,500
⋮		⋮		⋮
		UNDER	3,500	

The cumulative ask and bid quantities represent supply and demand, respectively, and one of the prices where supply and demand intersect becomes the projected execution price. In the above example, JPY 539 and JPY 538 serve as candidate prices, and **these prices are set as the Q1 quote information**. Furthermore, a major difference from the order book during continuous

trading (Zaraba) is that in **the quantity fields for Q1, the ask quote quantity is set to the cumulative ask quantity, and the bid quote quantity is set to the cumulative bid quantity.** During Itayose (call auction), the Q1 quote flag is set to '0', which represents 'Quote Before Opening'. (Explanations of the quote flag set values are described later in Section 3.10.)

While there are minor exception patterns, you can generally track changes in the indicative execution price using the information in the Q1 quotes.

(Q1 Ask and Bid Value Example in the Order Book Above)

Q1_ASK			Q1_BID		
PRICE	QUOTE FLAG	VOLUME	PRICE	QUOTE FLAG	VOLUME
539	0	5,900	538	0	6,600

3.9. Reconstructing Order Book History

Because this dataset maintains 'UPDATE_NUM' field with absolute sequential integrity, order book information can be reconstructed in exact chronological order. Furthermore, although limited to 10 levels on each side (bids and asks), because data is retained in the form of snapshots at each point in time, simply displaying the snapshot information sequentially according to the 'UPDATE_NUM' allows you to replay order book transitions like a flipbook (frame-by-frame).

The need to verify market conditions at the time of order execution ex-post arises not only for trading analysis, but also for compliance review and auditing purposes.

To reconstruct order book states beyond the top 10 levels, FLEX MBO Historical data is required; however, because its message format differs significantly, a distinct processing approach is necessary.

3.10. Quote Flags: Values & Concrete Order Book Examples

While collectively referred to as 'quotes', several distinct types exist in addition to General Quotes registered on the order book during continuous trading (Zaraba), there are quotes during the order acceptance period prior to the market opening—where orders cannot directly match—as well as Special Quotes and Sequential Trade Quotes displayed to mitigate rapid price volatility. In backtesting trading strategies, for instance, scenarios arise where it is necessary to distinguish whether a given quote was executable (matchable). This dataset includes quote flags ('Q1 Ask Quote Flag' and 'Q1 Bid Quote Flag') for the best ask and best bid quotes, enabling

users to determine whether each quote was executable. The meanings and concrete examples for each quote flag setting are outlined below.

[Quote Flag Value and Explanation]

0: Quote Before Itayose (Quote before Call Auction)

- Indicates that the quote was registered prior to the market opening for the morning session opening, afternoon session opening, or closing auction (*during Pre-Closing session in the case of the closing auction).
- For the morning and afternoon session openings, even after the trading session start time (e.g., after 09:00 for the morning session), quotes are delivered as "0" (Quote Before Itayose) until the opening execution (the first trade of that session) is established.

1: General Quote

- Indicates that the quote was registered after the market opening.

2: General Quote (Under Transaction)

- Set during continuous trading (Zaraba) when quote changes caused by a single incoming order are in progress. For example, if an incoming sell market order executes across multiple price levels changing the execution price from JPY 509 → JPY 508 → JPY 507 → JPY 506, the Bid Quote Flag in the records at the execution moments for JPY 509, JPY 508, and JPY 507 is set to 2 (General Quote (Under Transaction)). The Bid Quote Flag in the record at the execution moment for JPY 506 is set to 1 (General Quote). Please refer to the following order book transition example.

[Example of General Quote (Under Transaction) – A sell market order of 1,100 units arrives at the following order book]

ACCUM VOLUME	ASK VOLUME	PRICE	BID VOLUME		ACCUM VOLUME
	↘ 1,100	MARKET ORDER			
13,200	9,600	OVER			
⋮		⋮			⋮
1,400	700	537			
700	200	530			
500	200	519			
300	300	517			
		<u>513</u>			
		509	500		500
		508	100		600
		507	100		700
		506	400		1,100
		501	200		1,300
⋮		⋮			⋮
		UNDER	9,100		12,900

↓

ACCUM VOLUME	ASK VOLUME	PRICE	BID VOLUME	ACCUM VOLUME
		MARKET ORDER		
13,200	9,600	OVER		
⋮		⋮		⋮
1,400	700	537		
700	200	530		
500	200	519		
300	300	517		
		509	~~500~~	Execution or 1,100 units
		508	~~100~~	
		507	~~100~~	
		506	~~400~~	
		501	200	200
⋮		⋮		⋮
		UNDER	9,100	11,800

[Representation in 10-Level Order Book Historical Data –

Excerpt showing Trading Volume, Bid Quotes, and Bid Quote Flags]

Event	Price	ACCUM. TRADED VOLUME	Q1_ BID PRICE	Q1_ BID VOL	BID QUOTE FLAG	Q2_ BID PRICE	Q2_ BID VOL	Q3_ BID PRICE	Q3_ BID VOL
BEFORE ARRIVAL OF SELL MARKET ORDER	513	100	509	500	1	508	100	507	100
ARRIVAL OF SELL MARKET ORDER, TRADE AT 509 (UNDER TRANSACTION)	509	600	508	100	2	507	100	506	400
TRADE AT 508 (UNDER TRANSACTION)	508	700	507	100	2	506	400	501	200

TRADE AT 507 (UNDER TRANSACTION)	507	800	506	400	2	501	200	500	200
TRADE AT 506 (TRANSACTION COMPLETE)	506	1,200	501	200	1	500	200	496	100

3: Special Quote

- On the Tokyo Stock Exchange (TSE), a transaction is executed immediately only if the price falls within a "specified price range" compared to the immediately preceding price. This "specified price range" is called the Special Quote Parameter and is established based on the last traded price (reference price). When an ask quote and a bid quote match at a price level exceeding the Special Quote Parameter from the reference price, the trade is not executed immediately; instead, a "Special Quote" is displayed within the Special Quote Parameter to solicit contra-side orders.

[\[Reference\] Trading Rules of Domestic Stocks | Japan Exchange Group](#)

- Quote information delivered as a Special Quote is not based on an actual order. Please note during backtest that orders cannot match against a Special Quote.
- While a Special Ask Quote (Special Sell Quote) is displayed, the Bid Quote Flag is set to 1 (General Quote). While a Special Bid Quote (Special Buy Quote) is displayed, the Ask Quote Flag is set to 1 (General Quote).

4: Sequential Trade Quote

- On the Tokyo Stock Exchange (TSE), if executions driven by a single incoming order sweep the order book upwards (or downwards) beyond a specified price range (twice the Special Quote Parameter) from the last traded price, further executions are halted. At this point, a Sequential Trade Quote is displayed for one minute to solicit contra-side orders.
- [\[Reference\] Methodology of Individual auctions | Japan Exchange Group](#)
- Quote information delivered as a Sequential Trade Quote is not based on an actual order, and orders cannot match against a Sequential Trade Quote. Please pay attention to this during backtest and analysis.
 - While a Sequential Ask Quote (Sequential Sell Quote) is displayed, the Bid Quote Flag is set to 1 (General Quote). While a Sequential Bid Quote (Sequential Buy Quote) is displayed, the Ask Quote Flag is set to 1 (General Quote).

5: Temporary Quote at Start of Pre-Closing

- In conjunction with the system upgrade of the equities trading system "arrowhead" in November 2024, a Closing Auction was introduced to enhance transparency in closing price formation. The Closing Auction applies to transactions executed at the end of the afternoon trading session.
- Under the current rules, Pre-Closing takes place starting at 15:25 prior to the Closing Auction. During Pre-Closing, market participants can submit new orders or modify existing orders, but no actual trade executions take place. Upon completion of Pre-Closing, the Closing Auction is promptly conducted; when trades are executed during the auction, that execution price becomes the closing price for the day.
- Quote Flag "5" is delivered if a Special Quote, Sequential Trade Quote, Special Quote Before Trading Halt, or Sequential Trade Quote Before Trading Halt is active at the moment Pre-Closing starts.
- Because on-close conditional orders are registered on the order book at the start of Pre-Closing, the order book state may change significantly. Consequently, quote information is cleared once at 15:25, and the updated order book state is populated. Because timestamp inversion may occur at this moment, please be sure to refer to the 'UPDATE_NUM' field.

6: Quote After Special Execution

- "Special Execution" refers to executing trades—with the objective of enhancing opportunities to establish a closing price—when trades cannot be executed through the standard call auction or stop allocation during the call auction at the close of the afternoon trading session (for example, when orders match outside the allowable execution price range for the close), provided that the conditions for Special Execution are satisfied.
[\[Reference\] Methodology of Individual auctions | Japan Exchange Group](#)
- This quote flag is delivered when a sell order or buy order becomes subject to trade allocation through Special Execution.

7: Special Quote Before Trading Halt

- Delivered when trading is halted or suspended while a Special Quote is displayed.

8: Sequential Trade Quote Before Trading Halt

- Delivered when trading is halted or suspended while a Sequential Trade Quote is displayed.

Book Reference

Guide to TSE Trading Methodology 2024 Edition

This book provides a clear and detailed explanation of the price formation logic adopted in the Tokyo Stock Exchange's equities trading system 'arrowhead' through a total of 76 selected practical examples.