

WIBID AND WIBOR UNDER THE BENCHMARK REGULATION

Consultation Paper



Warsaw, July 2019

Table of Contents

2.	ORGANISATIONAL CHANGES IN CALCULATION AND PUBLICATION	7
3.	RELATED MARKETS	8
4.	WATERFALL METHOD	10
4.1	Assumptions	10
4.2	Waterfall Levels.....	12
4.3	Specific calculation rules.....	12
4.4	Bid/Offer Spread Calculation	22
5	WATERFALL METHOD BASELINE VARIANT PARAMETERS	24
6	WIBOR INDEX FIXING CALCULATION	26
7	SIMULATION RESULTS	27
7.1	Baseline variant.....	27
7.2	Increase of the Incremental Parameter to 2	31
7.3	Increase of the volume eligibility thresholds of Transactions for Related Markets to PLN 2 million	35
7.4	Decrease of the volume eligibility thresholds of Transactions to PLN 0 million (no volume eligibility thresholds).....	39
7.5	Addition of the Large Enterprises Sector as a related market with a volume eligibility threshold of PLN 2 million	43
8	MATERIAL CHANGE VERIFICATION METHOD RESULTS.....	47
8.1	Changes to the Definition of the Reference Rates	47
8.2	Change of the Reference Rates Method	47
8.3	Materiality Criteria	48
8.4	Verification results.....	48
9.	SUMMARY	53

GLOSSARY

Capitalised terms used in this Consultation Paper have the following meaning:

Term	Meaning
Administrator	GPW Benchmark S.A. with a registered office in Warsaw, ul. Książęca 4, 00-498 Warsaw, entered into the register of entrepreneurs of the National Court Register by the District Court for the capital city of Warsaw in Warsaw, 12 th Commercial Division under KRS no. 0000493097; with share capital of PLN 2,900,000 - fully paid up; NIP 5252546511
Analytical Procedures	procedures used in the Waterfall Method: Allocation of Fixing Tenors to Transactions; Interpolation of Quotes with the Spread Adjustment Factor; Allocation of Fixing Tenors to Transactions with Non-fixing Tenors; Extrapolation of Prices from Related Markets to the Reference Market; Bid/Offer Spread Calculation
BMR	Regulation (EU) 2016/1011 of the European Parliament and of the Council of 8 June 2016 on indices used as benchmarks in financial instruments and financial contracts or to measure the performance of investment funds and amending Directives 2008/48/EC and 2014/17/EU and Regulation (EU) No 596/2014
Business Day	a calendar day, other than a Saturday or a statutory holiday, including Sundays, during which the Fixing Participants operate on the Polish money market
Committed Quote	a Quote which is the result of Level 4 of the Waterfall Method. A Committed Quote includes a Bid Rate and an Offer Rate
Deposit	an unsecured deposit in the Polish zloty (PLN), accepted or placed by a Fixing Participant on the Reference Market or on a Related Market
Eligible Transaction	a transaction whose volume is equal to or greater than the volume eligibility threshold set by the Administrator
Fixing	the procedure of determining the WIBOR Index by the Administrator
Fixing Date	a Business Day during which a WIBOR Index Fixing takes place
Fixing Participant	an entity which has received confirmation of having been granted Fixing Participant status from the Administrator
Fixing Tenors	tenors for which a WIBOR Index Fixing is carried out
Input Data	input data within the meaning of Article 3(1)(14) of the BMR, provided to the Administrator by Fixing Participants, used by the Administrator to carry out WIBOR Index Fixing
Key Elements of the Method	the key elements of the measurement method of a market or economic conditions defined by the Administrator
Material Change	a material change within the meaning of Article 13(1)(c) of the BMR
Material Change Verification Method	a method to be used by the Administrator to verify whether changes made to the Administrator's WIBOR Index calculation method are a Material Change
Materiality Criteria	quantitative criteria used by the Administrator in the Material Change Verification Method
Model Quote	a Quote which is the result of Levels 1, 2 and 3 of the Waterfall Method. A Model Quote includes a Bid Rate and an Offer Rate
Non-fixing Tenors	tenors other than Fixing Tenors
Extrapolation of Prices from Related Markets to the Reference Market	A statistical procedure of estimating the value of Transaction Factor determined on the Reference Market from the Transactions concluded on the Related Market
Interpolation of Quotes with the Spread Adjustment Factor	a procedure of interpolating Model Quotes
Bid/Offer Spread Calculation	analytical procedure used by Fixing Participants to determine the Spread and apply it in the Transaction Factor, resulting in

	the calculation of a Model Quote including a Model Quote Bid Rate and Offer Rate
Allocation of Fixing Tenors to Transactions with Non-Fixing Tenors	analytical procedure of allocating exactly two transactions with a Fixing Tenor, described by a price and a volume, to each Eligible Transaction with a Non-fixing Tenor
Quote	Input Data containing a simultaneous Quote for a given Fixing Tenor by a Fixing Participant of a Bid Rate and an Offered Rate on a given day. Quotes mean Model Quotes and/or Committed Quotes
Reference Market	a market of transactions in unsecured deposits in the Polish zloty (PLN) concluded between WIBID/WIBOR Fixing Participants, and transactions in unsecured deposits in the Polish zloty (PLN) concluded between WIBID/WIBOR Fixing Participants and credit institutions which are not WIBID/WIBOR Fixing Participants
Related Markets	segments of the money market, included in the assumptions of the Waterfall Method, considered by the Administrator to be markets extrapolated to the Reference Market. Related Markets include: - Financial Institutions Segment ("FI") which includes transactions in unsecured deposits in the Polish zloty (PLN) concluded between WIBID/WIBOR Fixing Participants and pension, insurance and investment institutions or mortgage banks, co-operative banks and co-operative savings and loans associations - Other Financial Institutions Segment ("OFI") which includes transactions in unsecured deposits in the Polish zloty (PLN) concluded between WIBID/WIBOR Fixing Participants and financial institutions other than pension, insurance and investment institutions or mortgage banks, co-operative banks and co-operative savings and loans associations
Segment	a separate part of the market which may become a Related Market
Spread	the difference between an Offer Rate of a Quote and a Bid Rate of a Quote
Transaction, Deposit Transaction	a transaction in a Deposit
Transaction Data	data concerning Deposit Transactions concluded by Fixing Participants, used by Fixing Participants to determine Model Quotes by means of the Waterfall Method
Transaction Factor	a scalar value which is the result of the Waterfall Method at Levels 1, 2 and 3, used as the basis of application of the Bid/Offer Spread Calculation in order for a Fixing Participant to determine the Model Quote Bid Rate and Offer Rate
Waterfall Method	a method used by Fixing Participants to determine Input Data
WIBID	benchmark for bid rates from Quotes calculated during a Fixing according to the Regulations for the WIBID and WIBOR Reference Rates
WIBID/WIBOR Adjustment / Adjustment of the Calculation Method of the WIBID/WIBOR Reference Rates	analytical works related to the adjustment of the calculation method of the WIBID/WIBOR reference rates to the requirements of the BMR, aiming to carry out economic, statistical and legal analyses necessary to verify assumptions and implement adjustment necessary to continue the provision of the WIBID/WIBOR reference rates by the Administrator in accordance with the requirements of the BMR after the transitional period in order to maintain the current definition of the reference market and the key elements of the method
WIBOR	benchmark for offer rates from Quotes calculated during a Fixing according to the Regulations for the WIBID and WIBOR Reference Rates

WIBOR Index	index developed during the WIBID/WIBOR Adjustment process in compliance with the BMR rules regarding interest rate benchmarks, yet upholding the key elements of the methodology of the WIBID and WIBOR reference rates
--------------------	---

1. BACKGROUND

Over the last months, the GPW Benchmark has carried out economic, statistical and legal analyses in order to meet the BMR requirements while ensuring the continuity of the WIBID and WIBOR reference rates.¹

The analytical process led to a construction of a theoretical WIBOR Index. The WIBOR Index represents an idea of the WIBID and WIBOR reference rates developed in compliance with the BMR rules regarding interest rate benchmarks, yet upholding the key elements of the methodology of the WIBID and WIBOR reference rates. The objective of GPW Benchmark as the entity acting as the WIBID and WIBOR reference rate Administrator² was to ensure compliance with the BMR requirements for interest rate benchmarks while mitigating the risk of their discontinuity.

Furthermore, the analysis was to verify the working hypothesis that the WIBOR Index, subject to GPW Benchmark's analysis, is in principle identical to the WIBID and WIBOR reference rates.

The WIBOR Index calculation method was based on the Waterfall Method, where Input Data in the form of Fixing Participant Quotes are prepared using transaction data, if available, appropriate and sufficient to reliably represent the market or economic reality that a benchmark intends to measure.

The method presented in this Consultation Paper is a compilation of necessary adjustments and the enforcement of certain solutions and rules while maintaining, as a principle, the key elements of the WIBID and WIBOR Reference Rate calculation method and referring to the definition of the reference market, i.e., the market and economic conditions which are to be measured.

Quantitative and qualitative tests have been carried out, aimed at verifying whether the WIBOR Index reflects the WIBID and WIBOR reference rates, and thus, the economic, statistical and legal continuity of the latter, after the proposed adjustment is reassured.

The scope of the WIBID and WIBOR methodology adjustment enables gradual evolution of the WIBID and WIBOR Reference Rates in line with changing economic conditions, without undermining their continuity.

¹ Regulation (EU) 2016/1011 of the European Parliament and of the Council of 8 June 2016 on indices used as benchmarks in financial instruments and financial contracts or to measure the performance of investment funds and amending Directives 2008/48/EC and 2014/17/EU and Regulation (EU) No 596/2014

² After receiving authorization GPW Benchmark S.A. will become an Administrator of the reference rates WIBID and WIBOR in accordance with the BMR Regulation

2. ORGANISATIONAL CHANGES IN CALCULATION AND PUBLICATION

Organisational changes in the calculation and publication of ON and TN tenors of the WIBOR Index is a result of consultations with stakeholders and analytical work carried out regarding Adjustment of the Calculation Method of the WIBID/WIBOR Reference Rates to the BMR requirements. The objective of the organisational changes in question is to ensure a representative character and adequacy of Transaction Data used to calculate Model Quotes for the ON and TN tenors of the WIBOR Index.

The organisational changes in the calculation and publication of ON and TN tenors of the WIBOR Index are as follows:

- ◆ The WIBOR Index for ON and TN tenors is published at 17:00 on a Fixing Date.
- ◆ The calculation of the WIBOR Index for the ON and TN tenors on a Fixing Date is based on the following Transaction Data:
 - ✓ Transaction Data from the Reference Market for transactions concluded between 00:00 (midnight) on day T and 16:30 on day T.
 - ✓ Transaction Data from the Related Markets (Financial Institutions Segment and Other Financial Institutions Segment) for transactions concluded between 00:00 (midnight) on day T and 15:30 on day T.
- ◆ The WIBOR Index is not calculated or published for tenor 9M.

No organisational changes are expected for tenors SW, 2W, 1M, 3M, 6M and 1Y. The Waterfall Method presented in this Paper and the simulation results reported herein incorporate the organisational changes described above.

3. RELATED MARKETS

The markets which may hypothetically function as Related Markets, considered in the analytical work in the Adjustment of the Calculation Method of the WIBID/WIBOR Reference Rates to the BMR requirements, included the following segments:

- ◆ Financial Institutions Segment ("FI") which includes transactions in unsecured deposits in the Polish zloty (PLN) concluded between WIBID/WIBOR Fixing Participants and pension, insurance and investment institutions or mortgage banks, co-operative banks and co-operative savings and loans associations.
- ◆ Public Institutions Segment ("PI") which includes transactions in unsecured deposits in the Polish zloty (PLN) concluded between WIBID/WIBOR Fixing Participants and the Social Insurance Institution (ZUS), the Social Insurance Fund (FUS), the Demographic Reserve Fund (FRD), and the Bridging Retirement Pension Fund (FEP).
- ◆ Other Financial Institutions Segment ("OFI") which includes transactions in unsecured deposits in the Polish zloty (PLN) concluded between WIBID/WIBOR Fixing Participants and financial institutions other than pension, insurance and investment institutions or mortgage banks, co-operative banks and co-operative savings and loans associations.
- ◆ Enterprises Segment ("ES") which includes transactions in unsecured deposits in the Polish zloty (PLN) concluded between Fixing Participants and enterprises. Transactions in this Segment are split between two categories of entities: the Large Enterprises Segment ("ES-L"), which includes transactions between Fixing Participants and large enterprises (according to the FINREP classification); and the Small and Mid-sized Enterprises Segment ("ES-SME"), which includes transactions between Fixing Participants and small and mid-sized enterprises (according to the FINREP classification).

To identify those Segments which will be the source of transaction data used in the calculation of Quotes and the WIBOR Index, a range of analyses and tests were carried out, including:

- Analyses of statistical characteristics of transaction data from each Segment.
- Analyses of similarities between transaction data from each Segment and transaction data from the Reference Market.
- Historical simulations of the WIBOR Index performance based on alternative assumptions of the scope of Segments considered to be Related Markets in the Waterfall Method and alternative assumptions of the Waterfall Method parameters.
- Analyses of the impact of the assumptions on the transactionality³ and volatility of the WIBOR Index.

As an example of analyses carried out in order to assess the degree of similarity between the Segments and the Reference Market, *Table 1* presents a similarity metrics of centred⁴ distributions of average daily volume-weighted prices in respective Segments and centred distributions of average daily volume-weighted prices in the Reference Market. The metrics are based on test statistics of the Kolmogorov-Smirnov goodness of fit test ("KS"). KS metrics are presented for different values of the lower bound on volumes of transactions. *Table 1* presents the results with no lower bound of the volume (KS/0), for transactions with volumes of at least PLN 1 million (KS/1) and for transactions with volumes of at least PLN 20 million (KS/20).

A lower value of the KS metric represents a higher degree of similarity of centred distributions of average daily volume-weighted prices; a higher value of the KS metric represents a lower degree of similarity. Results suggest that the Public Institutions Segment and the Enterprises Segment show a lower degree of similarity of distributions of average daily volume-weighted prices to the Reference Market than the Financial Institutions Segment and the Other Financial Institutions Segment.

³ Transactionality of the WIBOR Index is understood as the frequency of use of transaction data in the Waterfall Method.

⁴ Centred means that the distribution average is brought to 0.

Segment	KS/0	KS/1	KS/20
FI	0.045	0.045	0.030
PI	0.204	0.204	0.198
OFI	0.051	0.046	0.080
ES	0.219	0.213	0.184
ES – L	0.210	0.210	0.190

Table 1. Similarity metrics of centred distributions of average daily volume-weighted prices in the Segments and in the Reference Market

The Related Markets whose transaction data are used to calculate Model Quotes within the Waterfall Method include two Segments:

- Financial Institutions Segment
- Other Financial Institutions Segment

Question 1: Do you agree with the selection of the Financial Institutions Segment and the Other Financial Institutions Segment as Related Markets?

4. WATERFALL METHOD

This section presents a description of the Waterfall Method used by Fixing Participants to calculate Input Data, i.e., Quotes.

4.1 Assumptions

Purpose of the Waterfall Method

The Waterfall Method is a method used by Fixing Participants to calculate Quotes provided to the Administrator, comprised of a Bid Rate and an Offer Rate for each Fixing Tenor. Quotes provided by Fixing Participants to the Administrator constitute Input Data used by the Administrator to carry out a WIBOR Index Fixing for each Fixing Tenor. A WIBOR Index Fixing includes the Fixing of a Bid Rate and the Fixing of an Offer Rate for each Fixing Tenor.

Quotes, Transaction Data Priority

The Waterfall Method comes in the form of an algorithm and, as such, it maps Input Data onto output data. The Input Data of the Waterfall Method are Transaction Data, if sufficient and adequate to precisely and reliably represent the market and economic conditions which are to be measured by the WIBOR Index benchmark. The output data of the Waterfall Method are Quotes. There are two types of quotes: Model Quotes and Committed Quotes.

According to the Waterfall Method:

- ♦ If a Fixing Participant has Transaction Data for a given Fixing Tenor on a given Fixing Date, which can be used to calculate a Quote for this Fixing Tenor on this Fixing Date, then the Quote is called a Model Quote. In that case, the output of the Waterfall Method is a Model Quote. Model Quotes correspond to Levels 1, 2 and 3 of the Waterfall Method. **Model Quotes are provided to the Administrator.**
- ♦ If a Fixing Participant has no Transaction Data for a given Fixing Tenor on a given Fixing Date, which could be used to calculate a Quote for the Fixing Tenor on the Fixing Date, then the output of the Waterfall Method provided by the Fixing Participant comes in the form of a Committed Quote of the Fixing Participant. In that case, the output of the Waterfall Method is a Committed Quote. Committed Quotes correspond to Level 4 of the Waterfall Method. **Committed Quotes are provided to the Administrator on each Fixing Date, irrespective of contribution of Model Quotes.**

As a result, the Waterfall Method follows the principle that Transaction Data have the highest priority as input data in the Quote calculation process.

It should be stressed that Quotes are calculated in the Waterfall Method for each Fixing Tenor separately. It may be that a Fixing Participant provides to the Administrator on a given Fixing Date Model Quotes for some tenors and Committed Quotes for other tenors. If no Model Quote can be provided, Committed Quotes provided independently on every Fixing Date are considered to be input data for the Fixing calculation.

Model Quotes and Committed Quotes

The calculation method of Fixing of the reference rates WIBID and WIBOR constantly uses Quotes provided by Fixing Participants as Input Data.

If a Fixing Participant can determine a Quote at Waterfall Levels 1 – 3 for a Fixing Tenor on a Fixing Date, then the Quote is a Model Quote.

If a Fixing Participant cannot calculate a Model Quote for a Fixing Tenor on a Fixing Date, then a Quote provided in the Contribution Window to the Administrator for that Fixing Tenor on that Fixing Date via WIBIX as an output of Waterfall Level 4 is considered to be the Quote provided for the Fixing Tenor on the Fixing Date. In that case, the Quote provided by the Fixing Participant is a Committed Quote.

Further to the foregoing, Committed Quotes provided in the Contribution Window are provided by Fixing Participants via WIBIX on each Fixing Date and are subject to the obligation to conclude a transaction if requested during the transaction window described in the Fixing Participants Code of Conduct.

Waterfall Levels – hierarchical and incremental

Hierarchical

The Waterfall Method is hierarchical. The Waterfall hierarchy is as follows:

- ◆ Transaction Data and, consequently, Model Quotes have a higher priority than Committed Quotes.
- ◆ Transaction Data from the Reference Market have a higher priority than Transaction Data from the Related Markets.
- ◆ In a given Segment, Transaction Data for Transactions with Fixing Tenors have a higher priority than Transaction Data for Transactions with Non-fixing Tenors.
- ◆ In the Reference Market, Model Quotes calculated on the basis of Transaction Data have a higher priority than Model Quotes calculated on the basis of interpolation.
- ◆ In the Related Markets, Transaction Data for the Segments of the Related Markets follow a hierarchy.

The Waterfall hierarchy implies that the Waterfall is divided into Levels 1, 2, 3 and 4 and their sublevels. As a result of the hierarchy, a Fixing Participant that implements the Waterfall Method calculates Quotes for a Fixing Tenor on a Fixing Date on the basis of Transaction Data, taking into account the Analytical Procedures, sourced from the highest possible Waterfall Levels; if that is not possible, the Fixing Participant's Committed Quotes are assumed to be an output of the Waterfall Method. In particular, Transaction Data from the Reference Market are used at higher Waterfall Levels than Transaction Data from the Related Markets; within the Related Markets, Transaction Data from the Financial Institutions Segment are used at higher Waterfall Levels than Transaction Data from the Other Financial Institutions Segment.

Question 2: Do you agree with the hierarchy of the Waterfall Method?

Incremental

Quotes and, consequently, Waterfall Method outputs are calculated according to the hierarchy of the Waterfall Levels described above. In addition, the Waterfall Method follows an incremental approach. The incremental approach implies that Model Quotes for a Fixing Tenor on a Fixing Date are calculated on the basis of a number of data points which is equal at least to the minimum number of data points imposed by the Incremental Parameter. Data points are Transaction Data for Waterfall Levels 1 – 3 or outputs of Analytical Procedures:

- ◆ For Waterfall Level 2: Interpolation of Quotes with the Spread Adjustment Factor, Allocation of Fixing Tenors to Transactions with Non-fixing Tenors.
- ◆ For Waterfall Level 3: Extrapolation of Prices from Related Markets to the Reference Market and Allocation of Fixing Tenors to Transactions with Non-fixing Tenors in combination with Extrapolation of Prices from Related Markets to the Reference Market.

A Fixing Participant applies the Waterfall Method by determining data points for a Fixing Tenor on a Fixing Date starting with Waterfall Level 1. If the number of data points which can be used to calculate a Model Quote at Waterfall Level 1 is smaller than the value of the Incremental Parameter, then the Fixing Participant moves to Waterfall Level 2. If the total number of data points which can be used to calculate a Model Quote at Waterfall Levels 1 and 2 is smaller than the value of the Incremental Parameter, then the Fixing Participant moves to Waterfall Level 3.

The process stops at that Waterfall Level at which the total number of data points from Level 1 to that Level is at least equal to the value of the Incremental Parameter. A Model Quote is calculated on the basis of the collected data points. If the total number of data points which can be used to calculate a Model Quote at Waterfall Levels 1, 2 and 3 is smaller than the value of the Incremental Parameter, then the Fixing Participant provides a Waterfall Level 4 Quote, i.e., a Committed Quote.

The Incremental Parameter values are positive integers. The Incremental Parameter may be equal to 1, which means that the incremental property of the Waterfall Method is not active.

Analytical Procedures

Model Quotes are calculated in the Waterfall Method (at Waterfall Levels 1, 2 and 3) by means of algorithmic transformation of Input Data into Model Quotes. The process involves the following Analytical Procedures:

- ✓ Extrapolation of Prices from Related Markets to the Reference Market.
- ✓ Interpolation of Quotes with the Spread Adjustment Factor.
- ✓ Bid/Offer Spread Calculation.
- ✓ Allocation of Fixing Tenors to Transactions.
- ✓ Allocation of Fixing Tenors to Transactions with Non-fixing Tenors;

The Analytical Procedures constitute elements of the Waterfall Method.

Transaction Factor and bilateral quotes

Model Quotes calculated by Fixing Participants for all Fixing Tenors in the Waterfall Method include a Bid Rate and an Offer Rate. The Bid/Offer Rates are calculated in a two-step way. First, the value of the Transaction Factor is determined. The Transaction Factor is calculated on the basis of Transaction Data and, when necessary, using the Analytical Procedures. Next, the Spread is calculated using the Bid/Offer Spread Calculation, and the Spread is applied to the Transaction Factor in order to calculate the Bid Rate and the Offer Rate of the Model Quote.

As an exception, Model Quotes at Waterfall Level 2.1 are calculated by interpolating Model Quotes calculated at Waterfall Level 1. In that case, the Model Quote Bid Rate and Offer Rate are calculated separately through interpolation.

Method implementation

The Waterfall Method is a responsibility of Fixing Participants. The Model Quote calculation method is identical for all Fixing Participants. The Waterfall Model Quote calculation algorithm is deterministic.

4.2 Waterfall Levels

Level 1 and 2 Model Quotes are calculated on the basis of Transaction Data from the Reference Market. Level 3 Model Quotes are calculated on the basis of Transaction Data from the Related Markets, which involves application of the extrapolation of the volume-weighted prices to the Reference Market. Table 2 summarises the Waterfall Levels.

The analysis of alternative specifications of the Waterfall Method also considered Waterfall Level 2.3 based on Transaction Data from the Reference Market for a specific number of days preceding day T-1 ("lookback period"). In particular, it considered a lookback period including days T-2, T-3, T-4, and T-5. Application of such lagged Transaction Data would require the Waterfall Method to apply an adjustment of prices for changes on the interbank market ("Market Adjustment Factor"). In the absence of an active market, e.g., in derivatives, necessary to implement such an adjustment factor, a Level based on a lookback period is not included in the Waterfall Method.

4.3 Specific calculation rules

Waterfall Level 1 – Eligible Transactions with Fixing Tenors from the Reference Market on day T-1

A Fixing Participant calculates TF_{P1} - the Transaction Factor at Waterfall Level 1 for a given Fixing Tenor on day T, on the basis of Eligible Transactions with Fixing Tenors equal to this Fixing Tenor, concluded by the Fixing Participant on the Reference Market on day T-1, provided that the number

of such Transactions is at least equal to the value of the Incremental Parameter. The Transaction Factor at Waterfall Level 1, TF_{P1} , is calculated according to the following formula:

$$TF_{P1} = \frac{\sum_i (r_{i,T-1} \times v_{i,T-1})}{\sum_i v_{i,T-1}}$$

where:

- $r_{i,T-1}$ stands for the price of the i -th transaction;
- $v_{i,T-1}$ stands for the volume of the i -th transaction.

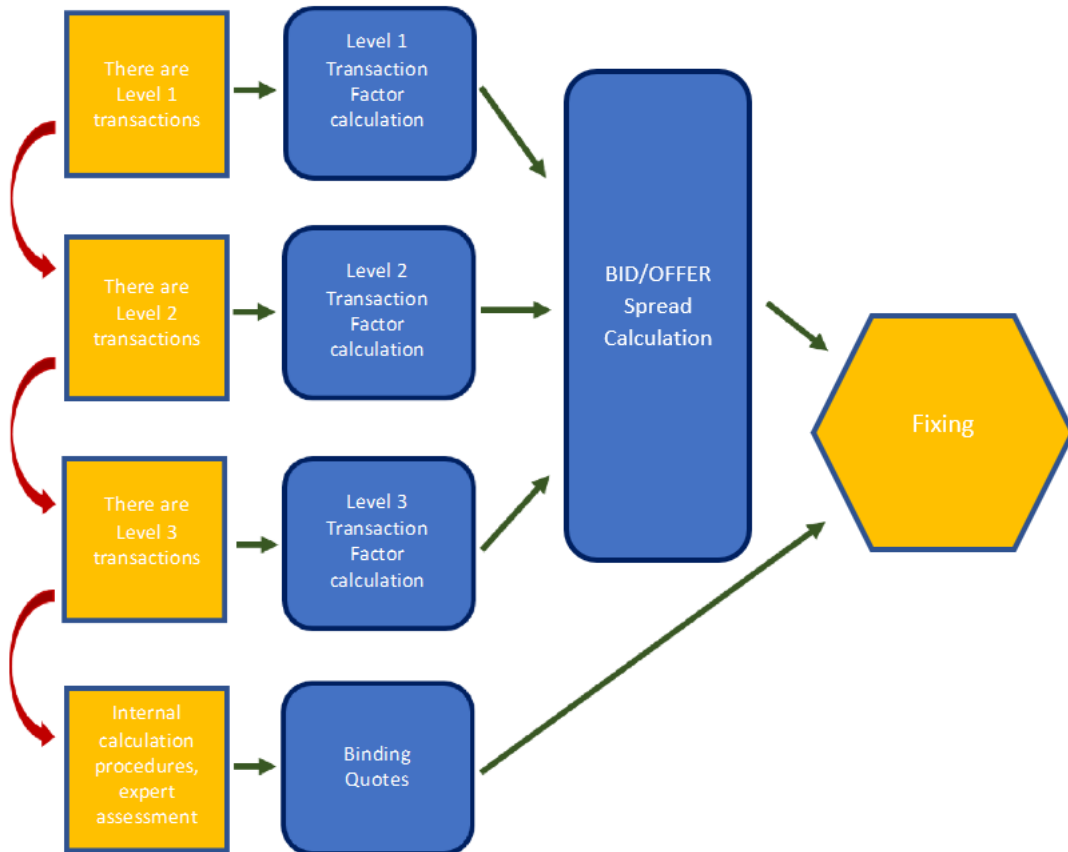


Figure 1. Waterfall Method Level hierarchy

After the Fixing Participant has calculated the Transaction Factor at Waterfall Level 1 for the Fixing Tenor in question on day T, the Fixing Participant applies the Bid/Offer Spread Calculation in order to calculate a Bid Rate and an Offer Rate of the Model Quote for this Fixing Tenor, which concludes the application of the Waterfall Method for this Fixing Tenor on day T.

Otherwise, the procedure to be followed by the Fixing Participant depends on the value of the Incremental Parameter.

If the Incremental Parameter is equal to 1, which is the case in the Waterfall Method baseline variant, then the Fixing Participant moves to Waterfall Level 2.1.

Level	Description
1	Model Quotes based on Eligible Transactions with Fixing Tenors from the Reference Market on day T-1.
2.1	Model Quotes resulting from interpolation of Level 1 Model Quotes on day T taking into account the Spread Adjustment Factor.
2.2	Model Quotes based on transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors from the Reference Market on day T-1.
3.1	Model Quotes based on Eligible Transactions from the Financial Institutions Segment on day T-1 taking into account the Extrapolation of Prices from Related Markets to the Reference Market.
3.2	Model Quotes based on transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors from the Financial Institutions Segment on day T-1 taking into account the Extrapolation of Prices from Related Markets to the Reference Market.
3.3	Model Quotes based on Eligible Transactions from the Other Financial Institutions Segment on day T-1 taking into account the Extrapolation of Prices from Related Markets to the Reference Market.
3.4	Model Quotes based on transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors from the Other Financial Institutions Segment on day T-1 taking into account the Extrapolation of Prices from Related Markets to the Reference Market.
4	Committed Quotes.

Table 2. Waterfall Levels in the Waterfall Method

If the Incremental Parameter is greater than 1, then the Fixing Participant proceeds as follows. If the number of Eligible Transactions with Fixing Tenors equal to the tenor in question, concluded by the Fixing Participant on the Reference Market on day T-1⁵, is smaller than the Incremental Parameter but greater than or equal to 1, then such Transactions are saved in the Waterfall Level 1 Transaction Set, denoted by TS_{L1} , and the Fixing Participant moves to Waterfall Level 2.1. If the number of Eligible Transactions with Fixing Tenors equal to the tenor in question, concluded by the Fixing Participant on the Reference Market on day T-1 is equal to 0, then it is assumed that $TS_{L1} = \emptyset$.

Waterfall Level 2

Allocation of Fixing Tenors to Transactions

The allocation of tenors to transactions uses the tenors for which the WIBOR Index is calculated, i.e.:

ON, TN, SW, 2W, 1M, 3M, 6M, 1Y.

⁵ In the case of tenors ON and TN, the above applies to Eligible Transactions concluded on day T, due to the change in the time of publication of the Fixing for tenors ON and TN.

Each transaction is allocated one (or none) of those tenors based on three dates:

- Transaction date.
- Value date.
- Maturity date.

To allocate tenors to transactions, differences (expressed in business days and expressed in calendar days) are calculated between:

- Transaction date and value date.
- Value date and maturity date.

The differences are used to allocate tenors to transactions according to the rules presented in Table 3.

Tenor	Business days ⁶		Calendar days ⁷	
	VALUE DATE - TRANSACTION DATE ⁸	MATURITY DATE - VALUE DATE ⁹	VALUE DATE - TRANSACTION DATE ¹⁰	MATURITY DATE - VALUE DATE ¹¹
ON	0 days	1 day	-	-
TN	1 day	1 day	-	-
SW	2 days	-	-	1W*
2W	0-2 days	-	-	2W*
1M	0-2 days	-	-	1M* +/- 5 days
3M	0-2 days	-	-	3M* +/- 10 days
6M	0-2 days	-	-	6M* +/- 30 days
1Y	0-2 days	-	-	1Y* +/- 30 days

Table 3. Rules of allocation of Fixing Tenors to transactions

Symbols 1W*, 2W* represent numbers of calendar days between the transaction's value date and the analogous weekday which falls 1 week and 2 weeks after the value date, respectively (unless it is not a Fixing Date, in which case the directly preceding Fixing Date is used).

Symbols 1M*, 3M*, 6M* and 1Y* represent numbers of calendar days between the transaction's value date and the date which falls 1, 3, 6 and 12 calendar months after the value date, respectively (unless it is not a Fixing Date, in which case the directly preceding Fixing Date is used).

Allocation of Fixing Tenors to Transactions with Non-fixing Tenors

Transactions to which tenors cannot be allocated using to the Allocation of Fixing Tenors to Transactions are called transactions with Non-fixing Tenors.

⁶ Difference expressed in business days.

⁷ Difference expressed in calendar days.

⁸ Difference between transaction date and value date.

⁹ Difference between maturity date and value date.

¹⁰ Difference between transaction date and value date.

¹¹ Difference between maturity date and value date.

To use Eligible Transactions with Non-fixing Tenors, an Eligible Transaction with a Non-fixing Tenor is allocated the two neighbouring Fixing Tenors. Let $\tau' < \tau < \tau''$ denote tenors, such that τ' and τ'' are Fixing Tenors directly neighbouring on a Non-fixing Tenor τ . Tenors are expressed in calendar days. Let x_τ denote a transaction with a Non-fixing Tenor τ . Let $x_{\tau'}$ and $x_{\tau''}$ denote transactions resulting from the allocation of x_τ to the Fixing Tenors τ' and τ'' . To do this, the volume of transaction x_τ , denoted by $v(x_\tau)$, has to be split into a volume allocated to transaction $x_{\tau'}$, denoted by $v(x_{\tau'})$, and a volume allocated to transaction $x_{\tau''}$, denoted by $v(x_{\tau''})$.

Let:

$$\phi = \frac{\tau'' - \tau}{\tau'' - \tau'}$$

be a multiplier equal to the fraction of a difference (expressed in calendar days) between the maturity date of tenor τ'' and the maturity date of tenor τ , to the difference (expressed in calendar days) between the maturity date of tenor τ'' and the maturity date of tenor τ' .

Volumes $v(x_{\tau'})$ and $v(x_{\tau''})$ are calculated according to the following formulae:

$$\begin{aligned} v(x_{\tau'}) &= \phi \times v(x_\tau) \\ v(x_{\tau''}) &= (1 - \phi) \times v(x_\tau) \end{aligned}$$

Transaction prices $x_{\tau'}$ and $x_{\tau''}$, denoted as $r(x_{\tau'})$ and $r(x_{\tau''})$ respectively, are calculated as follows. Let $x_{\tau'}^F$ and $x_{\tau''}^F$ denote arithmetic means of the Bid Rate Fixing on day T-1 and the Offer Rate Fixing on day T-1, for Fixing Tenors τ' and τ'' , respectively.

Let $f(\tau|x_{\tau'}^F, x_{\tau''}^F, \tau', \tau'')$ stand for the interpolation function given by the following formula:

$$f(\tau|x_{\tau'}^F, x_{\tau''}^F, \tau', \tau'') = x_{\tau'}^F + \frac{x_{\tau''}^F - x_{\tau'}^F}{\tau'' - \tau'} (\tau - \tau')$$

Let:

$$\Delta' = f(\tau|x_{\tau'}^F, x_{\tau''}^F, \tau', \tau'') - x_{\tau'}^F$$

and:

$$\Delta'' = x_{\tau''}^F - f(\tau|x_{\tau'}^F, x_{\tau''}^F, \tau', \tau'')$$

Prices $r(x_{\tau'})$ and $r(x_{\tau''})$ are calculated according to the following formulae:

$$r(x_{\tau'}) = r(x_\tau) - \Delta'$$

and:

$$r(x_{\tau''}) = r(x_\tau) + \Delta''$$

The Allocation of Fixing Tenors to Transactions with Non-fixing Tenors is used at Waterfall Levels 2.1, 3.1 and 3.4.

The Allocation of Fixing Tenors to Transactions with Non-fixing Tenors is used in the Waterfall Method only for Eligible Transactions with Non-fixing Tenors whose tenors fall between Fixing Tenors SW and 1Y.

Waterfall Level 2.1 - Interpolation of Quotes with the Spread Adjustment Factor

Interpolation can be applied only for Model Quotes for Fixing Tenors 2W, 1M, 3M and 6M. A Fixing Participant interpolates Model Quotes for a given Fixing Tenor on day T if the Fixing Participant has calculated Model Quotes for the two neighbouring Fixing Tenors at Waterfall Level 1 on the same day T:

- A Fixing Participant interpolates Model Quotes for Fixing Tenor 2W on day T if the Fixing Participant has calculated the Transaction Factor at Waterfall Level 1 for tenors SW and 1M and then, according to the Bid/Offer Spread Calculation, calculated Model Quotes for those tenors at Waterfall Level 1 in the form of a Bid Rate and an Offer Rate on day T.

- A Fixing Participant interpolates Model Quotes for Fixing Tenor 1M on day T if the Fixing Participant has calculated the Transaction Factor at Waterfall Level 1 for tenors 2W and 3M and then, according to the Bid/Offer Spread Calculation, calculated Model Quotes for those tenors at Waterfall Level 1 in the form of a Bid Rate and an Offer Rate on day T.
- A Fixing Participant interpolates Model Quotes for Fixing Tenor 3M on day T if the Fixing Participant has calculated the Transaction Factor at Waterfall Level 1 for tenors 1M and 6M and then, according to the Bid/Offer Spread Calculation, calculated Model Quotes for those tenors at Waterfall Level 1 in the form of a Bid Rate and an Offer Rate on day T.
- A Fixing Participant interpolates Model Quotes for Fixing Tenor 6M on day T if the Fixing Participant has calculated the Transaction Factor at Waterfall Level 1 for tenors 3M and 1Y and then, according to the Bid/Offer Spread Calculation, calculated Model Quotes for those tenors at Waterfall Level 1 in the form of a Bid Rate and an Offer Rate on day T.

The Bid Rate and the Offer Rate of the Quote are interpolated separately. Let τ denote the Fixing Tenor which is subject to interpolation. Let τ' denote a neighbouring Fixing Tenor directly shorter than τ , and let τ'' denote a neighbouring Fixing Tenor directly longer than τ .

Let x_{ψ}^S stand for the Bid Rate ($S = BID$) or the Offer Rate ($S = OFFER$) of the Model Quote calculated for Fixing Tenor ψ at Waterfall Level 1 on day T , where $\psi \in \{\tau', \tau''\}$. Linear interpolation of Rate S for Fixing Tenor τ , denoted by $x_{\tau}^{S,L}$, is calculated as the value of the interpolation function $f(\tau|x_{\tau'}^S, x_{\tau''}^S, \tau', \tau'')$:

$$x_{\tau}^{S,L} = f(\tau|x_{\tau'}^S, x_{\tau''}^S, \tau', \tau'')$$

according to the formula:

$$f(\tau|x_{\tau'}^S, x_{\tau''}^S, \tau', \tau'') = x_{\tau'}^S + \frac{x_{\tau''}^S - x_{\tau'}^S}{\tau'' - \tau'}(\tau - \tau')$$

After calculating linear interpolation of Rate S for Fixing Tenor τ , i.e. $x_{\tau}^{S,L}$, the Fixing Participant calculates the Spread Adjustment Factor for this Fixing Tenor, denoted by SAF_{τ}^S , as follows.

Let $y_{t,\psi}^S$ stand for the Bid Rate ($S = BID$) or the Offer Rate ($S = OFFER$) of the WIBOR Index Fixing at day t , where $t \in \{T-1, T-2, \dots, T-5\}$, for Fixing Tenor ψ , where $\psi \in \{\tau', \tau''\}$. The Spread Adjustment Factor is calculated according to the following formula:

$$SAF_{\tau}^S = \frac{1}{5} \times \sum_{k=1}^5 (y_{T-k,\psi}^S - f(\tau|y_{T-k,\tau'}^S, y_{T-k,\tau''}^S, \tau', \tau''))$$

Linear interpolation of Rate S for Fixing Tenor τ is adjusted with the Spread Adjustment Factor SAF_{τ}^S , which results in the calculation of a Model Quote at Waterfall Level 2.1 for Rate S of Fixing Tenor τ :

$$MQ_{\tau}^S = x_{\tau}^{S,L} + SAF_{\tau}^S$$

If a Fixing Participant calculates a Model Quote Bid Rate and a Model Quote Offer Rate at Waterfall Level 2.1 for the Fixing Tenor in question on day T , that concludes the application of the Waterfall Method for this Fixing Tenor on day T . Otherwise, the Fixing Participant moves to Waterfall Level 2.2.

Level 2.2 – Eligible Transactions with Non-fixing Tenors concluded on the Reference Market on day T-1

A Fixing Participant calculates the Transaction Factor at Waterfall Level 2.2 for a given Fixing Tenor on day T , denoted by $TF_{L2.2}$, on the basis of transactions contained in a Level 2.2 Transaction Set, denoted by $TS_{L2.2}$, calculated as follows.

- If the Incremental Parameter is equal to 1, then set $TS_{L2.2}$ contains transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors concluded by the Fixing Participant on the Reference Market on day T-1, to which the Fixing Tenor in question was allocated, denoted by $TS_{RM,NFIX}$:

$$TS_{L2.2} = TS_{RM,NFIX}$$

- If the Incremental Parameter is greater than 1, then set $TS_{L2.2}$ is a sum of set TS_{L1} and a set of transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors concluded by the Fixing Participant on the Reference Market on day T-1, to which the Fixing Tenor in question was allocated, denoted by $TS_{RM,NFIX}$:

$$TS_{L2.2} = TS_{L1} \cup TS_{RM,NFIX}$$

If the number of Transactions in set $TS_{P2.2}$ is at least equal to the value of the Incremental Parameter, the Transaction Factor $TF_{P2.2}$ is calculated according to the following formula:

$$TF_{L2.2} = \frac{\sum_{x \in TS_{L2.2}} (r_x \times v_x)}{\sum_{x \in TS_{L2.2}} v_x}$$

where:

- x denotes a transaction;
- r_x denotes the price of transaction x ;
- v_x denotes the volume of transaction x .

After the Fixing Participant has calculated a Waterfall Level 2.2 Transaction Factor for a Fixing Tenor in question on day T, the Fixing Participant moves to the application of the Bid/Offer Spread Calculation in order to calculate the Model Quote Bid Rate and Offer Rate for this tenor, which concludes the application of the Waterfall Method for this Fixing Tenor on day T.

Otherwise, the Fixing Participant moves to Waterfall Level 3.1.

Waterfall Level 3

Extrapolation of Prices from Related Markets to the Reference Market

Let $TS_{Rel,t}$ denote – for Waterfall Levels 3.1 and 3.3 – a set of Eligible Transactions with a given Fixing Tenor concluded by a Fixing Participant on Related Market $Rel \in \{FI, OFI\}$ on day $t \in \{T-2, T-3, \dots, T-21\}$ or – for Waterfall Levels 3.2 and 3.4 – a set of transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors concluded by the Fixing Participant on Related Market $Rel \in \{FI, OFI\}$ on day $t \in \{T-2, T-3, \dots, T-21\}$, which are allocated the Fixing Tenor in question. If the Fixing Participant concludes no transactions on Related Market RP on day t , then it is assumed that $TS_{Rel,t} = \emptyset$. It is required that $TS_{Rel,t} \neq \emptyset$ for at least three days out of $t \in \{T-2, T-3, \dots, T-21\}$. Otherwise, the Fixing Participant cannot extrapolate prices for the tenor in question from the Related Market to the Reference Market on day T.

Let Γ stand for a set of such days t for which $TS_{Rel,t} \neq \emptyset$:

$$\Gamma = \{t \in \{T-2, T-3, \dots, T-21\} : TS_{Rel,t} \neq \emptyset\}$$

Let:

$$TS_{Rel} = \bigcup_{t \in \Gamma} TS_{Rel,t}$$

It is required that set TS_{Rel} has at least 5 elements. Otherwise, the Fixing Participant cannot extrapolate prices for the tenor in question from the Related Market to the Reference Market on day T.

Let $x_{Rel,t}^*$ denote the average volume-weighted price of Eligible Transactions with a Fixing Tenor in question concluded by the Fixing Participant on Related Market Rel on day t :

$$x_{Rel,t}^* = \frac{\sum_{x \in TS_{Rel,t}} (r_x \times v_x)}{\sum_{x \in TS_{Rel,t}} v_x}$$

The value of $x_{Rel,t}^*$ can be calculated for such days t for which $TS_{Rel,t} \neq \emptyset$, i.e. for $t \in \Gamma$. Since it is required that $ZT_{RP,t} \neq \emptyset$ for at least 3 days t , the value of $x_{Rel,t}^*$ can be calculated for at least 3 days t . For such days t , let m_t denote an arithmetic mean of the Committed Quote Bid Rate and the Committed Quote Offer Rate of the Fixing Participant for the Fixing Tenor in question on day t .

Let:

$$\Delta_{Rel,t} = m_t - x_{Rel,t}^*$$

stand for the difference between the arithmetic mean of the Committed Quote Bid Rate and the Committed Quote Offer Rate of the Fixing Participant for the Fixing Tenor in question on day t and the average volume-weighted price of Eligible Transactions with a Fixing Tenor concluded by the Fixing Participant on Related Market Rel on day t .

Let:

$$\bar{\Delta}_{Rel} = \frac{1}{|\Gamma|} \sum_{t \in \Gamma} \Delta_{Rel,t}$$

The value of $\bar{\Delta}_{Rel}$ is the extrapolation factor for which average volume-weighted prices of transactions on Related Market Rel on day $T-1$ are extrapolated to the Reference Market according to the following formula:

$$x_{RM,T-1}^* = x_{Rel,T-1}^* + \bar{\Delta}_{Rel}$$

where $x_{Rel,T-1}^*$ stands for the average volume-weighted price on the Related Market on day $T-1$ and $x_{RM,T-1}^*$ stands for the average volume-weighted price on day $T-1$ extrapolated from the Related Market to the Reference Market.

Level 3.1 - Eligible Transactions with Fixing Tenors concluded in the Financial Institutions Segment on day T-1

A Fixing Participant calculates the Transaction Factor at Waterfall Level 3.1 for a given Fixing Tenor on day T, denoted by $TF_{L3.1}$, on the basis of Eligible Transactions contained in the Level 3.1 Transaction Set, denoted by $TS_{L3.1}$, calculated as follows.

- If the Incremental Parameter is equal to 1, then set $TS_{L3.1}$ consists of Eligible Transactions with Fixing Tenors equal to the Fixing Tenor in question, concluded by the Fixing Participant in the Financial Institutions Segment on day T-1, denoted by $TS_{FI,FIK}$:

$$TS_{L3.1} = TS_{FI,FIK}$$

- If the Incremental Parameter is greater than 1, then set $TS_{L3.1}$ constitutes a sum of the set $TS_{L2.2}$ and a set of Eligible Transactions with Fixing Tenors equal to the Fixing Tenor in question, concluded by the Fixing Participant in the Financial Institutions Segment on day T-1, denoted by $TS_{FI,FIK}$:

$$TS_{L3.1} = TS_{L2.2} \cup TS_{FI,FIK}$$

If the number of Transactions in set $TS_{L3.1}$ is at least equal to the value of the Incremental Parameter, the Waterfall Level 3.1 Transaction Factor $TF_{L3.1}$ is calculated by applying the Extrapolation of Prices from Related Markets to the Reference Market to the average volume-weighted price of transactions contained in the set $TS_{L3.1}$, denoted by $m_{L3.1}$, calculated according to the following formula:

$$m_{L3.1} = \frac{\sum_{x \in TS_{L3.1}} (r_x \times v_x)}{\sum_{x \in TS_{L3.1}} v_x}$$

where:

- x denotes a transaction;
- r_x denotes the price of transaction x ;
- v_x denotes the volume of transaction x .

After the Fixing Participant has calculated a Waterfall Level 3.1 Transaction Factor for a Fixing Tenor in question on day T, the Fixing Participant moves to the application of the Bid/Offer Spread Calculation in order to calculate the Model Quote Bid Rate and Offer Rate for this Fixing Tenor, which concludes the application of the Waterfall Method for this Fixing Tenor on day T.

Otherwise, the Fixing Participant moves to Waterfall Level 3.2.

Level 3.2 - Eligible Transactions with Non-fixing Tenors concluded in the Financial Institutions Segment on day T-1

A Fixing Participant calculates the Transaction Factor at Waterfall Level 3.2 for a given Fixing Tenor on day T, denoted by $TF_{L3.2}$, calculated as follows.

- If the Incremental Parameter is equal to 1, then set $TS_{L3.2}$ contains transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors concluded by the Fixing Participant in the Financial Institutions Segment on day T-1, to which the Fixing Tenor in question was allocated,, denoted by $TS_{FI,NFIX}$:

$$TS_{L3.2} = TS_{FI,NFIX}$$

- If the Incremental Parameter is greater than 1, then set $TS_{L3.2}$ constitutes a sum of the set $TS_{L3.1}$ and a set of transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors concluded by the Fixing Participant in the Financial Institutions Segment on day T-1, to which the Fixing Tenor in question was allocated, denoted by $TS_{FI,NFIX}$:

$$TS_{L3.2} = TS_{L3.1} \cup TS_{FI,NFIX}$$

If the number of Transactions contained in the set $TS_{L3.2}$ is at least equal to the value of the Incremental Parameter, the Waterfall Level 3.2 Transaction Factor $TF_{L3.2}$ is calculated by applying the Extrapolation of Prices from Related Markets to the Reference Market to the average volume-weighted price of transactions in set $TS_{L3.2}$, denoted by $m_{L3.2}$, calculated according to the following formula:

$$m_{L3.2} = \frac{\sum_{x \in TS_{L3.2}} (r_x \times v_x)}{\sum_{x \in TS_{L3.2}} v_x}$$

where:

- x denotes a transaction;
- r_x denotes the price of transaction x ;
- v_x denotes the volume of transaction x .

After the Fixing Participant has calculated a Waterfall Level 3.2 Transaction Factor for the Fixing Tenor in question on day T, the Fixing Participant moves to the application of the Bid/Offer Spread Calculation in order to calculate the Model Quote Bid Rate and Offer Rate for the Fixing Tenor in

question, which concludes the application of the Waterfall Method for the Fixing Tenor in question on day T.

Otherwise, the Fixing Participant moves to Waterfall Level 3.3.

Level 3.3 - Eligible Transactions with Fixing Tenors concluded in the Other Financial Institutions Segment on day T-1

A Fixing Participant calculates the Transaction Factor at Waterfall Level 3.3 for a given Fixing Tenor on day T, denoted by $TF_{L3.3}$, on the basis of Eligible Transactions in Level 3.3 Transaction Set, denoted by $TS_{L3.3}$, calculated as follows.

- If the Incremental Parameter is equal to 1, then set $TS_{L3.3}$ contains Eligible Transactions with Fixing Tenors concluded by the Fixing Participant in the Other Financial Institutions Segment on day T-1, denoted by $TS_{OFI, FIX}$

$$TS_{L3.3} = TS_{OFI, FIX}$$

- If the Incremental Parameter is greater than 1, then set $TS_{L3.3}$ is a sum of set $TS_{L3.3}$ and a set of Eligible Transactions with Non-fixing Tenors concluded by the Fixing Participant in the Other Financial Institutions Segment on day T-1, denoted by $TS_{OFI, FIX}$:

$$TS_{L3.3} = TS_{L3.2} \cup TS_{OFI, FIX}$$

If the number of Transactions in set $TS_{L3.3}$ is at least equal to the Incremental Parameter, the Waterfall Level 3.3 Transaction Factor $TF_{L3.3}$ is calculated by applying the Extrapolation of Prices from Related Markets to the Reference Market to the average volume-weighted price of transactions in set $TS_{L3.3}$, denoted by $m_{L3.3}$, according to the following formula:

$$m_{L3.3} = \frac{\sum_{x \in TS_{L3.3}} (r_x \times v_x)}{\sum_{x \in TS_{L3.3}} v_x}$$

where:

- x denotes a transaction;
- r_x denotes the price of transaction x ;
- v_x denotes the volume of transaction x .

After the Fixing Participant calculates a Waterfall Level 3.3 Transaction Factor for a Fixing Tenor on day T, the Fixing Participant moves to the application of the Bid/Offer Spread Calculation in order to calculate the Model Quote Bid Rate and Offer Rate for the tenor, which concludes the application of the Waterfall Method for the Fixing Tenor on day T.

Otherwise, the Fixing Participant moves to Waterfall Level 3.4.

Level 3.4 - Eligible Transactions with Non-fixing Tenors concluded in the Other Financial Institutions Segment on day T-1

A Fixing Participant calculates the Transaction Factor at Waterfall Level 3.4 for a Fixing Tenor on day T, denoted by $TF_{L3.4}$, calculated as follows.

- If the Incremental Parameter is equal to 1, then set $TS_{L3.4}$ contains transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors concluded by the Fixing Participant in the Other Financial Institutions Segment on day T-1, which are allocated a Fixing Tenor, denoted by $TS_{OFI, NFIX}$:

$$TS_{L3.4} = TS_{OFI, NFIX}$$

- If the Incremental Parameter is greater than 1, then set $TS_{L3.4}$ is a sum of set $TS_{L3.3}$ and a set of transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-fixing Tenors to Eligible Transactions with Non-fixing Tenors concluded by the Fixing Participant in the Other Financial Institutions Segment on day T-1, which are allocated a Fixing Tenor, denoted by $TS_{OFI,NFIX}$:

$$TS_{L3.4} = TS_{L3.3} \cup TS_{OFI,NFIX}$$

If the number of Transactions in set $TS_{L3.4}$ is at least equal to the Incremental Parameter, the Waterfall Level 3.4 Transaction Factor $TF_{L3.4}$ is calculated by applying the Extrapolation of Prices from Related Markets to the Reference Market to the average volume-weighted price of transactions in set $TS_{L3.4}$, denoted by $m_{L3.4}$, according to the following formula:

$$m_{L3.4} = \frac{\sum_{x \in TS_{L3.4}} (r_x \times v_x)}{\sum_{x \in TS_{L3.4}} v_x}$$

where:

- x denotes a transaction;
- r_x denotes the price of transaction x ;
- v_x denotes the volume of transaction x .

After the Fixing Participant calculates a Waterfall Level 3.4 Transaction Factor for a Fixing Tenor on day T, the Fixing Participant moves to the application of Bid/Offer Spread Calculation in order to calculate the Model Quote Bid Rate and Offer Rate for the tenor, which concludes the application of the Waterfall Method for the Fixing Tenor on day T.

Otherwise, the Fixing Participant moves to Waterfall Level 4.

Waterfall Level 4 – Committed Quotes

If a Fixing Participant cannot calculate Waterfall Level 1 - 3 Quotes for a given Fixing Tenor on day T, the Fixing Participant's Committed Quotes are assumed as its Quotes for the Fixing Tenor in question on day T,¹² provided independently on each Fixing Date.

4.4 Bid/Offer Spread Calculation

The starting point for the application of Bid/Offer Spread Calculation is the Transaction Factor calculated at Waterfall Level 1, 2.2 or 3.1 – 3.4. The Bid/Offer Spread Calculation determines the Bid Rate and the Offer Rate, i.e. the Model Quotes, on the basis of the Transaction Factor.

Let TF_T denote a Transaction Factor calculated by a Fixing Participant for a given Fixing Tenor on day T. Let o_t stand for the Committed Quote Offer Rate of the Fixing Participant for the Fixing Tenor in question on day $t \in \{T-1, T-2, \dots, T-5\}$, and let b_t stand for the Committed Quote Bid Rate of the Fixing Participant for the Fixing Tenor on day $t \in \{T-1, T-2, \dots, T-5\}$.

Let:

$$s_T = \frac{1}{5} \sum_{k=1}^5 (o_{T-k} - b_{T-k})$$

denote an arithmetic mean of the spread between the Committed Quote Offer Rate and Committed Quote Bid Rate of the Fixing Participant on days $T-1, T-2, \dots, T-5$.

¹² Recommendations concerning the procedure of preparation and verification of Committed Quotes, including the application of expert judgement, will be described in the provisions of the Code of Conduct of Fixing Participants.

The Model Quote Bid Rate, denoted by B_T , and the Model Quote Offer Rate, denoted by O_T , are calculated by the Fixing Participant for a Fixing Tenor in question, on the basis of Transaction Factor FT_T according to the following formulae:

$$B_T = TF_T - \frac{S_T}{2}$$
$$O_T = TF_T + \frac{S_T}{2}$$

5 WATERFALL METHOD BASELINE VARIANT PARAMETERS

The Waterfall Method uses seven parameters. The frequency of use of Transaction Data in the calculation of Quotes increases or decreases depending on the values of parameters. The values of the parameters in the Waterfall Method baseline variant are presented below (Table 4); they provide the basis for a perturbation analysis of the parameters around the baseline specification.

Parameters of volume thresholds on the Reference Market (VET_RM) and the Related Markets (VET_FI, VET_OFI)

The Waterfall Method baseline variant sets volume thresholds of PLN 1 million on the Reference Market and PLN 1 million on the Related Markets.

♦ **Incremental Parameter (IP)**

The Incremental Parameter determines the minimum number of transactions (taking into account the Analytical Procedures), i.e., the minimum number of data points, necessary to calculate a Model Quote¹³. The Incremental Parameter allows to mitigate, if required, the impact of single transactions on the value of the Transaction Factor and, therefore, on its volatility. The incremental approach implies that data points at subsequent Waterfall Levels are cumulated until the resulting number of data points is equal to or greater than the value of the parameter, or until Waterfall Levels 1 – 3 are exhausted.

The analysis of alternative values of the Incremental Parameter of the Waterfall Method at the current stage of Adjustment of the WIBID and WIBOR Reference Rates suggests a significant decrease of the transactionality of the method, measured by the frequency of the use of Waterfall Method Levels other than Committed Quotes (i.e., of Levels 1 – 3), compared to the parameters used in the baseline variant of the method.

Further to the foregoing, the Incremental Parameter in the baseline variant of the Waterfall Method is assumed to be equal to 1. The analysis of the impact of changes to the Incremental Parameter will be verified during the review of the calculation method of the WIBID and WIBOR Reference Rates, including potential extension of the list of related markets in the specification of the Waterfall Method.

The stability of the Waterfall Method results is improved by implementing volume thresholds and Parameters of the Extrapolation of Prices from Related Markets to the Reference Market.

♦ **Parameters of the Extrapolation of Prices from Related Markets to the Reference Market**

The Extrapolation of Prices from Related Markets to the Reference Market adjusts the average daily volume-weighted prices of Eligible Transactions with Fixing Tenors concluded on a Related Market or transactions resulting from the application of the Allocation of Fixing Tenors to Transactions with Non-Fixing Tenors to Eligible Transactions with Non-Fixing Tenors concluded on a Related Market, using an average difference between average daily volume-weighted prices of transactions on the Related Market and the corresponding arithmetic means of the Committed Quote Bid Rate and Offer Rate of the Fixing Participant calculated on the basis of observations available on a given number of Fixing Dates preceding the day on which the Model Quote is calculated (historical Fixing Dates). Three parameters are used:

- Parameter of the minimum number of transactions necessary for the Extrapolation Procedure (MNT). The parameter of the minimum number of transactions necessary for the Extrapolation Procedure is set at 5 transactions.
- Parameter of the minimum number of historical days of transactions – minimum number of transaction days necessary for the Extrapolation Procedure (MNH). The parameter of the minimum number of historical transaction days necessary for the Extrapolation Procedure is set at 3 days.

¹³ The Incremental Parameter does not apply to Waterfall Level 2.1.

- Parameter of the length of the period of historical Fixing Dates necessary for the Extrapolation Procedure (HP). The parameter of the length of the period of historical Fixing Dates necessary for the Extrapolation Procedure is set at 20 days.

Changes in the value of the parameters impact the stability and responsiveness of the Extrapolation Procedure and the frequency of the use of Transaction Data in the Waterfall Method.

Parameter	Code	Value
Minimum transaction volume – Reference Market (PLN mn)	VET_RM	1
Minimum transaction volume – Financial Institutions Segment (PLN mn)	VET_FI	1
Minimum transaction volume – Other Financial Institutions Segment (PLN mn)	VET_OFI	1
Minimum number of transactions to calculate quotes for a Fixing Tenor (Incremental Parameter)	IP	1
Minimum number of transactions for the Extrapolation Procedure	MNT	5
Minimum number of historical Fixing Days for the Extrapolation Procedure	MNH	3
Period of historical Fixing Days for the Extrapolation Procedure	HP	20

Table 4. Waterfall Method baseline variant parameters

6 WIBOR INDEX FIXING CALCULATION

The average value of Quotes provided by Fixing Participants is calculated on each Fixing Date as follows:

- ♦ n - number of WIBOR Index Fixing Participants.
- ♦ x_i^S - Quote of i -th Fixing Participant for a given Fixing Tenor for Rate S on a given Fixing Date, where $i = 1, 2, \dots, n$, $S \in \{BID, OFFER\}$.
- ♦ X - a set $\{x_i, i = 1, 2, \dots, n\}$ from which m lowest elements and m highest elements have been excluded.¹⁴

The average value of Quotes of Fixing Participants for a Fixing Tenor in question on a Fixing Date in question, denoted by w^S , is calculated according to the following formula:

$$w^S = \frac{1}{n - 2m} \sum_{x \in X} x_i$$

¹⁴ If the number of Fixing Participants is at least equal to 10, then $m = 2$; if the number of Fixing Participants is equal to 8 or 9, then $m = 1$; if the number of Fixing Participants is lower than 8, then $m = 0$, according to the method presented in the Regulations for WIBID and WIBOR Reference rates.

7 SIMULATION RESULTS

This section presents selected results of experiments simulating the performance of the WIBOR Index from January 2016 to December 2018. The simulation results are compared with the historical performance of the WIBID/WIBOR Reference Rates. The results are presented for the Waterfall Method baseline variant (A) and for the following alternative variants:

- B. Increase of the Incremental Parameter to 2.
- C. Increase of the volume eligibility thresholds of Transactions for Related Markets to PLN 2 million.
- D. Decrease of the volume eligibility thresholds of Transactions to PLN 0 million (no volume eligibility thresholds for the Reference Market and the Related Markets).
- E. Introduction of the Large Enterprises Sector as a related market with a volume eligibility threshold of PLN 2 million; the volume eligibility thresholds for the Reference Market and the Financial Institutions and Other Financial Institutions remain unchanged at PLN 1 million.

The transactionality of the WIBOR Index is reported for each simulation variant, broken down by Fixing Tenor and Waterfall Level. WIBOR Index performance for tenors ON, 1M and 3M is presented in figures. Simulations are based on data provided by each Fixing Participant under the Historical Data Provision Agreement with the appendices and the Data Provision Procedure attached to the Code of Conduct of WIBID and WIBOR Reference Rate Fixing Participants.

7.1 Baseline variant

TENOR/LEVEL	L-1	L-2.1	L-2.2	L-3.1	L-3.2	L-3.3	L-3.4	L-4	TL
ON	90.11%	0.00%	0.00%	6.33%	0.00%	0.29%	0.00%	3.27%	96.73%
TN	13.55%	0.00%	0.00%	7.61%	0.00%	0.00%	0.00%	78.84%	21.16%
SW	2.33%	0.00%	0.85%	0.00%	5.75%	0.00%	2.83%	88.24%	11.76%
2W	1.37%	0.03%	1.40%	7.37%	8.91%	1.01%	4.81%	75.10%	24.90%
1M	1.17%	0.01%	0.61%	10.45%	7.78%	6.96%	6.26%	66.75%	33.25%
3M	0.77%	0.00%	0.13%	2.30%	3.52%	2.57%	8.91%	81.79%	18.21%
6M	0.00%	0.00%	0.00%	0.29%	0.11%	0.76%	0.57%	98.27%	1.73%
1Y	0.31%	0.00%	0.00%	0.19%	0.00%	0.27%	0.01%	99.23%	0.77%

Table 5. Variant A. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols L-1 to L-4 represent the Waterfall Levels. Symbol TL represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.

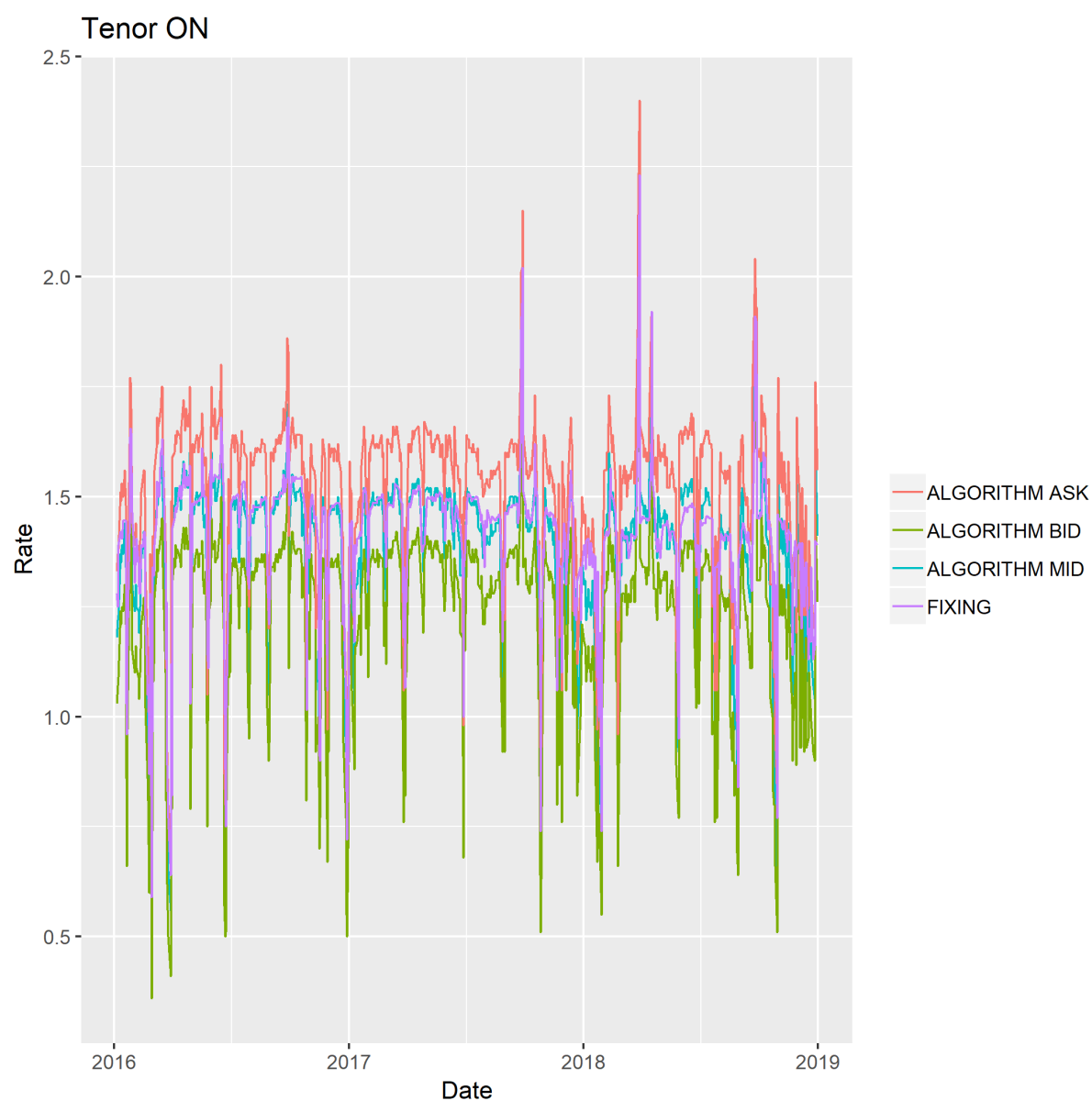


Figure 2. Variant A. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor ON. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.



Figure 3. Variant A. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 1M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

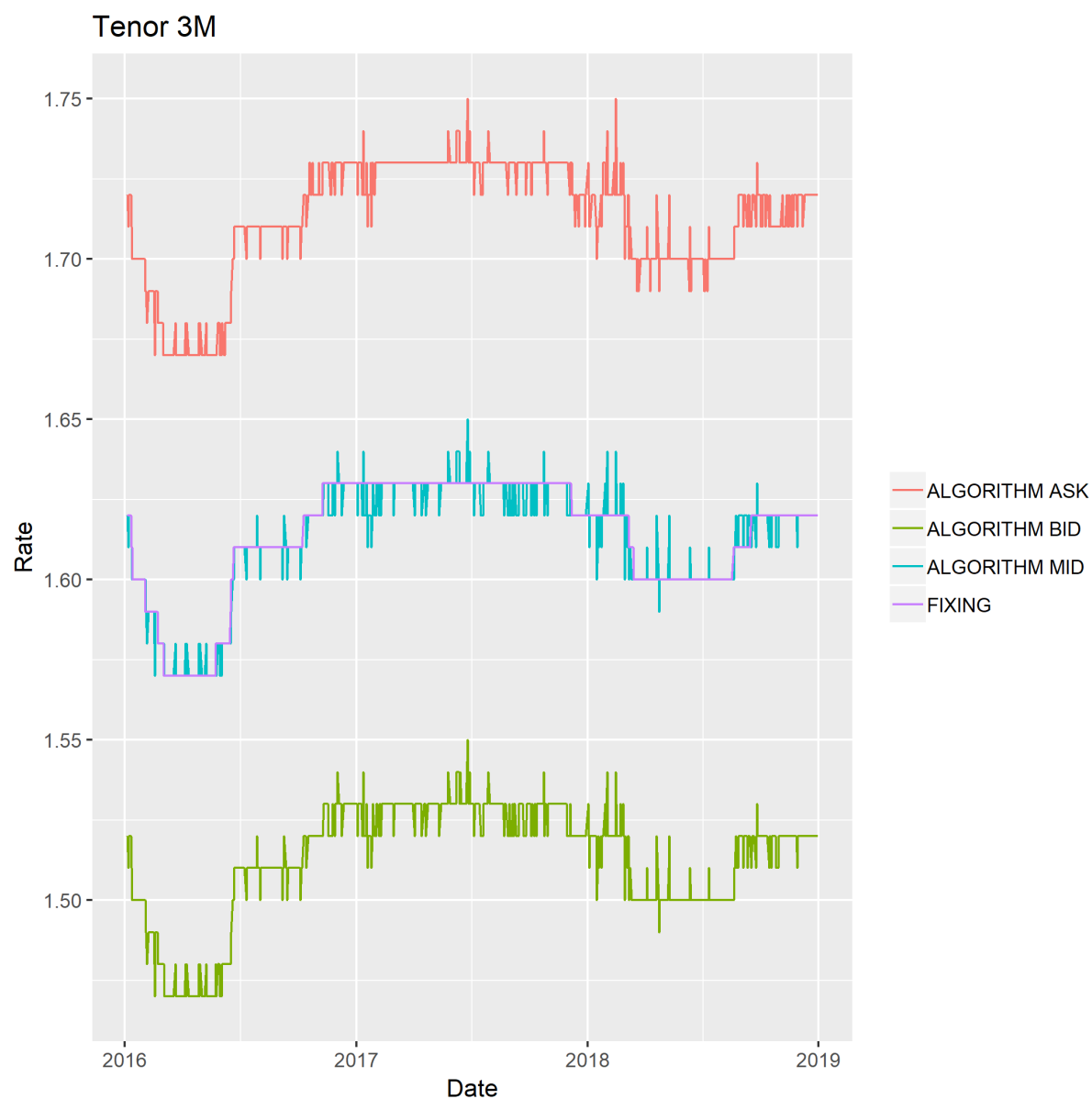


Figure 4. Variant A. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 3M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

7.2 Increase of the Incremental Parameter to 2

TENOR/LEVEL	L-1	L-2.1	L-2.2	L-3.1	L-3.2	L-3.3	L-3.4	L-4	TL
ON	76.34%	0.00%	0.00%	13.15%	0.00%	1.22%	0.00%	9.28%	90.72%
TN	2.79%	0.00%	0.00%	0.60%	0.00%	0.00%	0.00%	96.61%	3.39%
SW	0.61%	0.00%	0.17%	0.00%	2.50%	0.00%	1.21%	95.50%	4.50%
2W	0.00%	0.00%	0.11%	3.51%	6.20%	0.45%	2.97%	86.77%	13.23%
1M	0.04%	0.00%	0.01%	3.68%	4.87%	3.62%	5.36%	82.42%	17.58%
3M	0.03%	0.00%	0.05%	0.63%	1.10%	0.94%	4.18%	93.07%	6.93%
6M	0.00%	0.00%	0.00%	0.07%	0.03%	0.12%	0.23%	99.56%	0.44%
1Y	0.07%	0.00%	0.00%	0.05%	0.00%	0.15%	0.01%	99.72%	0.28%

Table 6. Variant B. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols P-1 to P-4 represent the Waterfall Levels. Symbol PT represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.

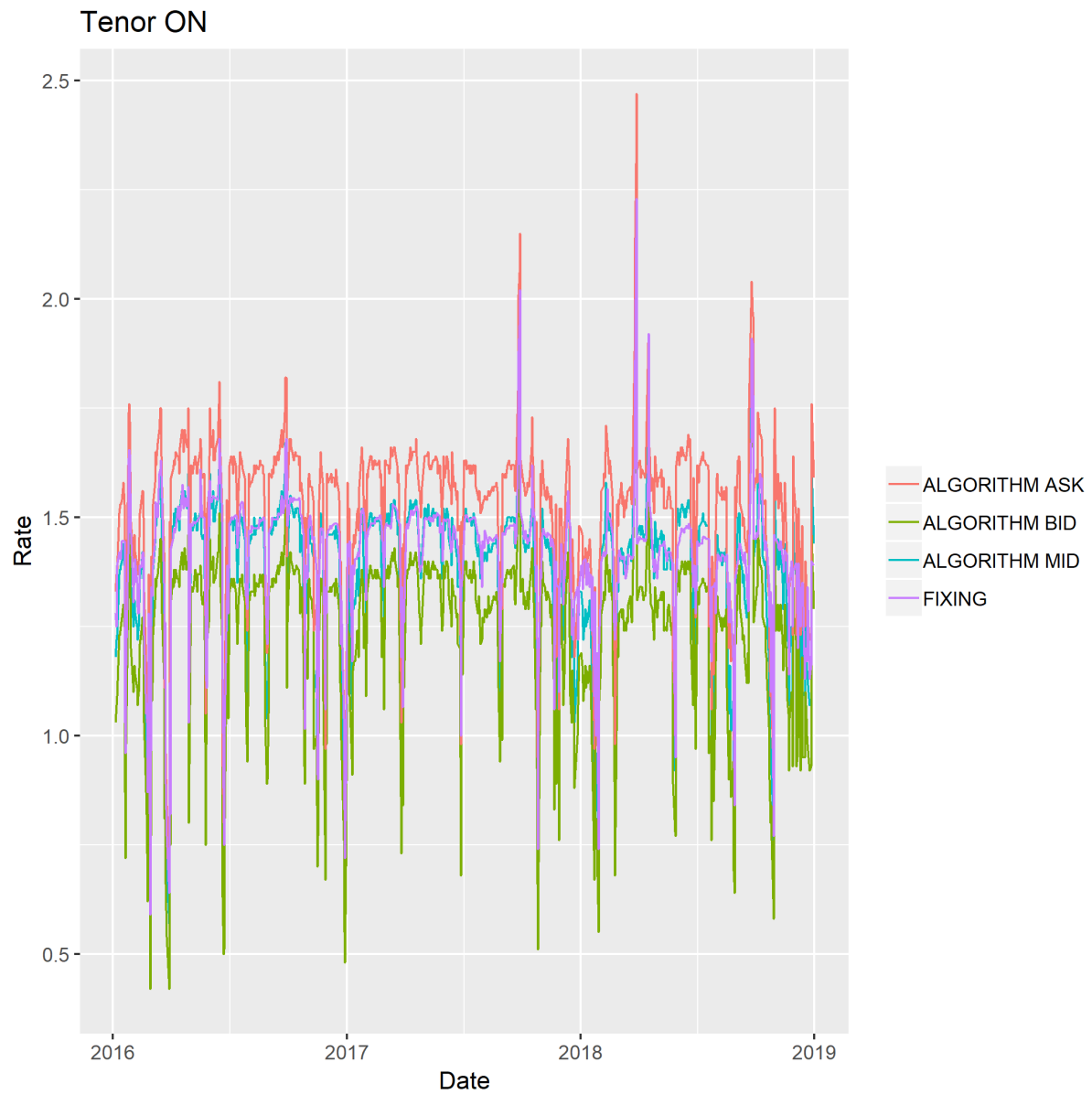


Figure 5. Variant B. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor ON. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

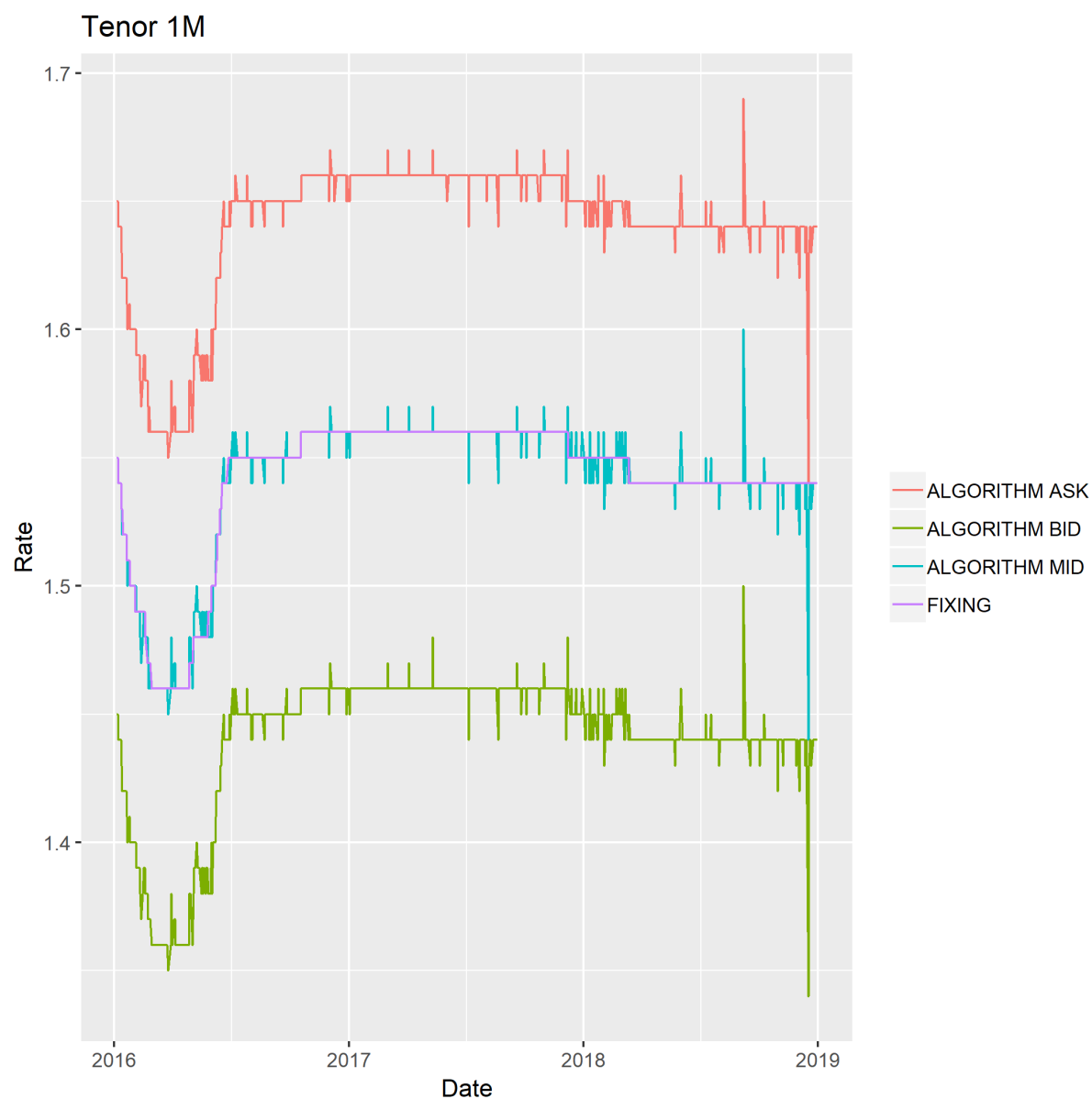


Figure 6. Variant B. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 1M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

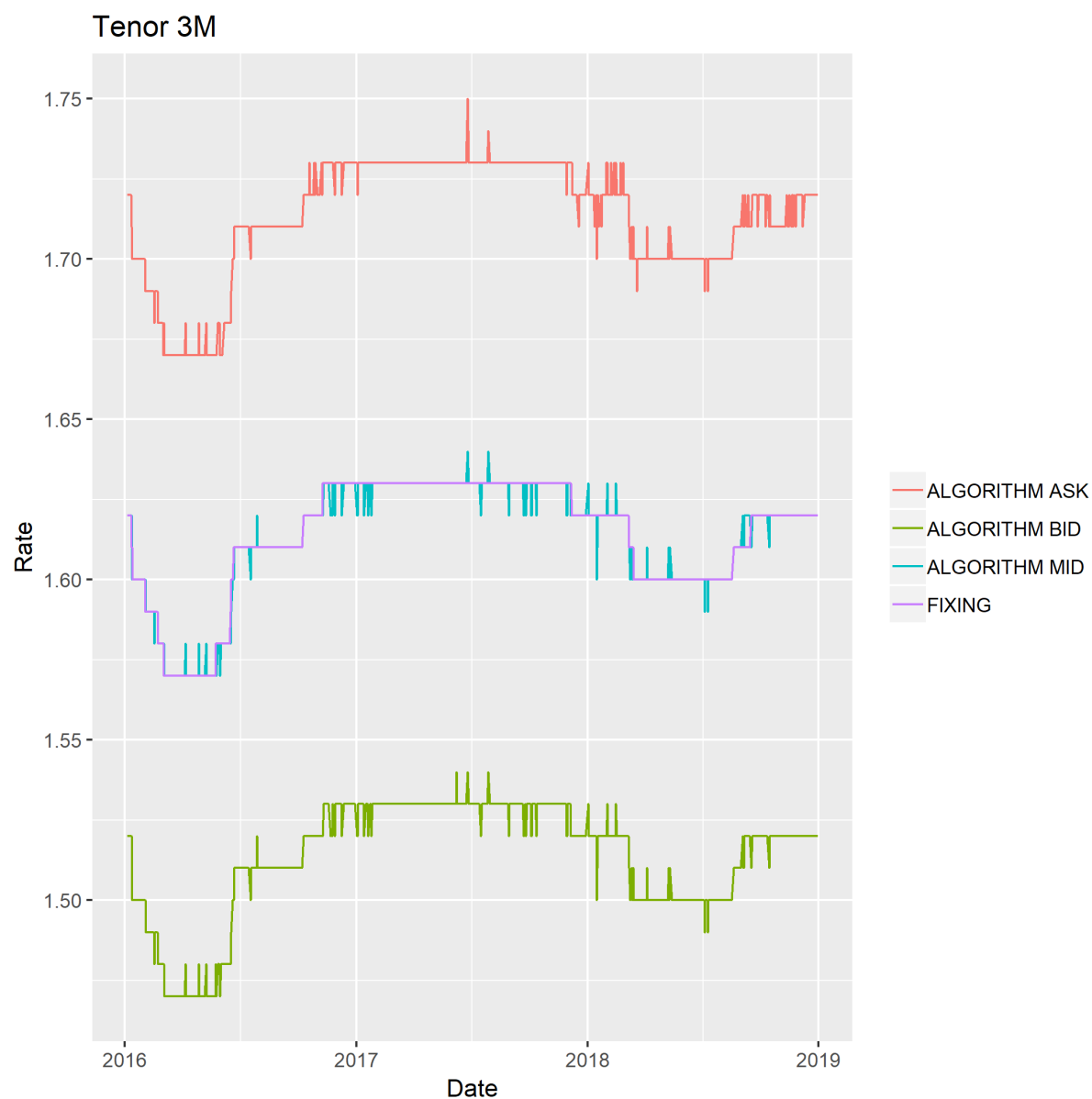


Figure 7. Variant B. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 3M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

7.3 Increase of the volume eligibility thresholds of Transactions for Related Markets to PLN 2 million

TENOR/LEVEL	L-1	L-2.1	L-2.2	L-3.1	L-3.2	L-3.3	L-3.4	L-4	TL
ON	90.11%	0.00%	0.00%	6.14%	0.00%	0.28%	0.00%	3.47%	96.53%
TN	13.55%	0.00%	0.00%	7.61%	0.00%	0.00%	0.00%	78.84%	21.16%
SW	2.33%	0.00%	0.85%	0.00%	4.02%	0.00%	1.84%	90.97%	9.03%
2W	1.37%	0.03%	1.40%	6.40%	7.59%	0.28%	3.91%	79.03%	20.97%
1M	1.17%	0.01%	0.61%	7.65%	6.81%	3.70%	3.21%	76.85%	23.15%
3M	0.77%	0.00%	0.13%	1.94%	2.50%	1.74%	3.36%	89.55%	10.45%
6M	0.00%	0.00%	0.00%	0.27%	0.08%	0.39%	0.48%	98.79%	1.21%
1Y	0.31%	0.00%	0.00%	0.17%	0.00%	0.07%	0.01%	99.44%	0.56%

Table 7. Variant C. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols P-1 to P-4 represent the Waterfall Levels. Symbol PT represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.

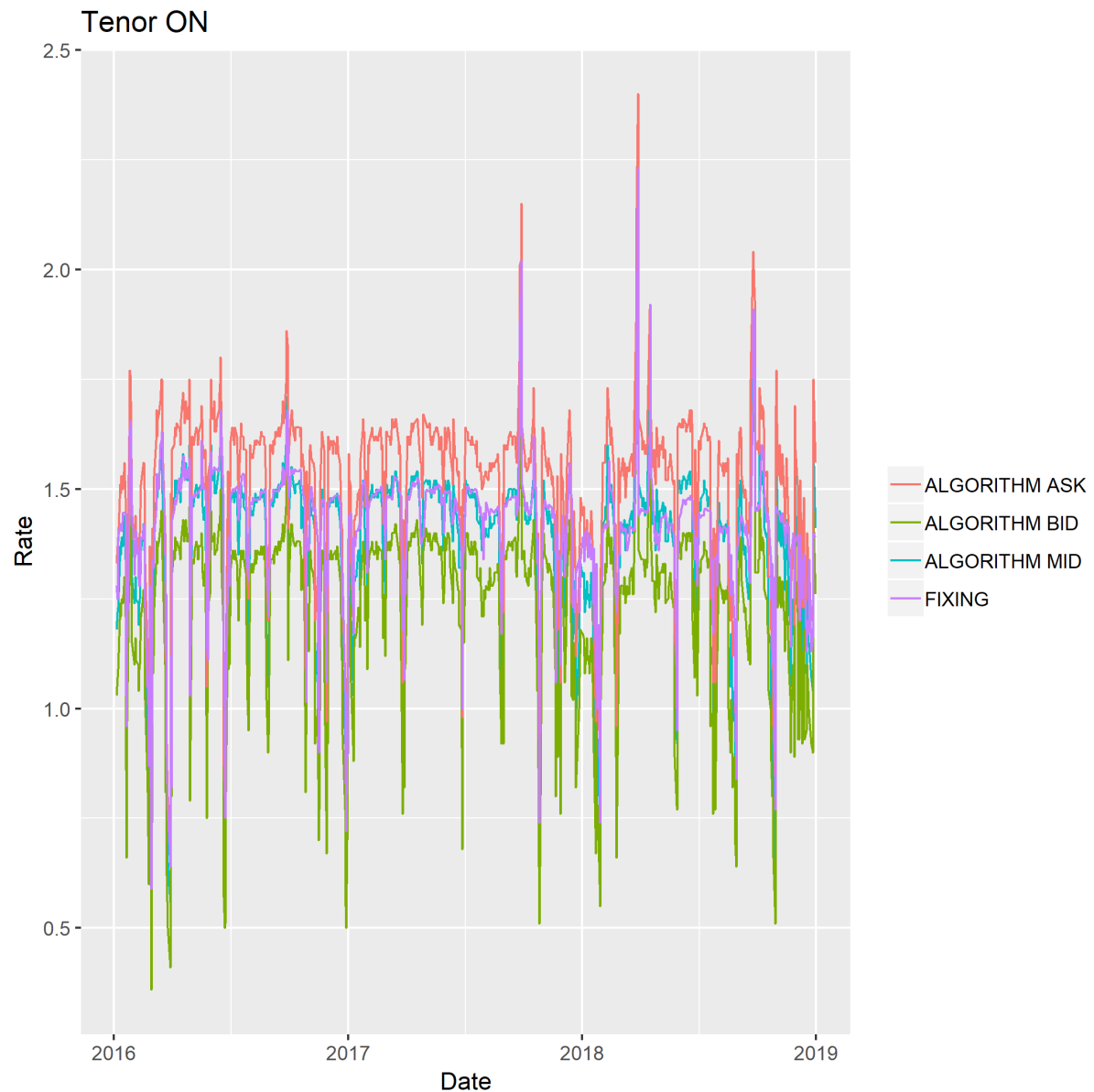


Figure 8. Variant C. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor ON. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

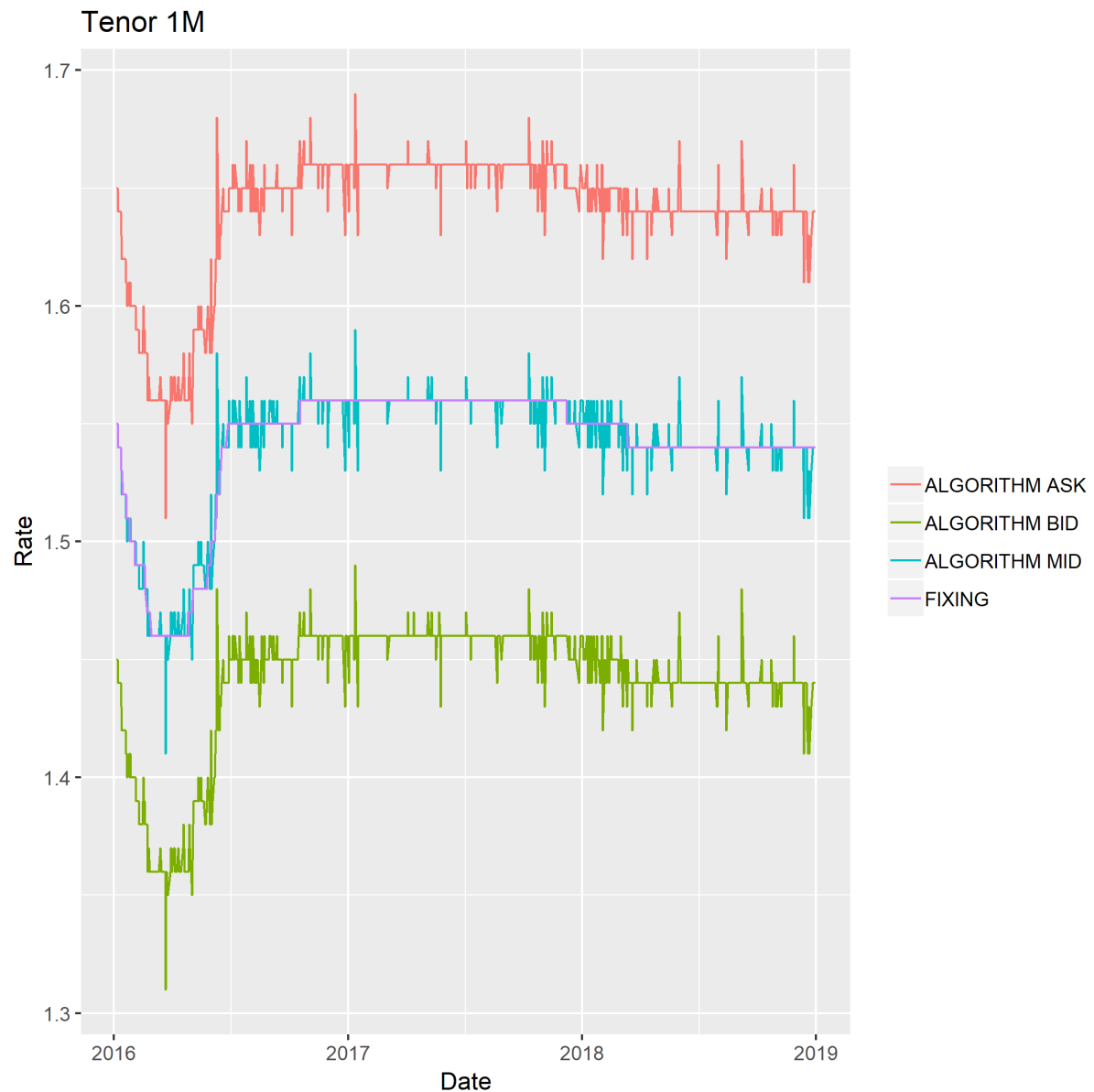


Figure 9. Variant C. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 1M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

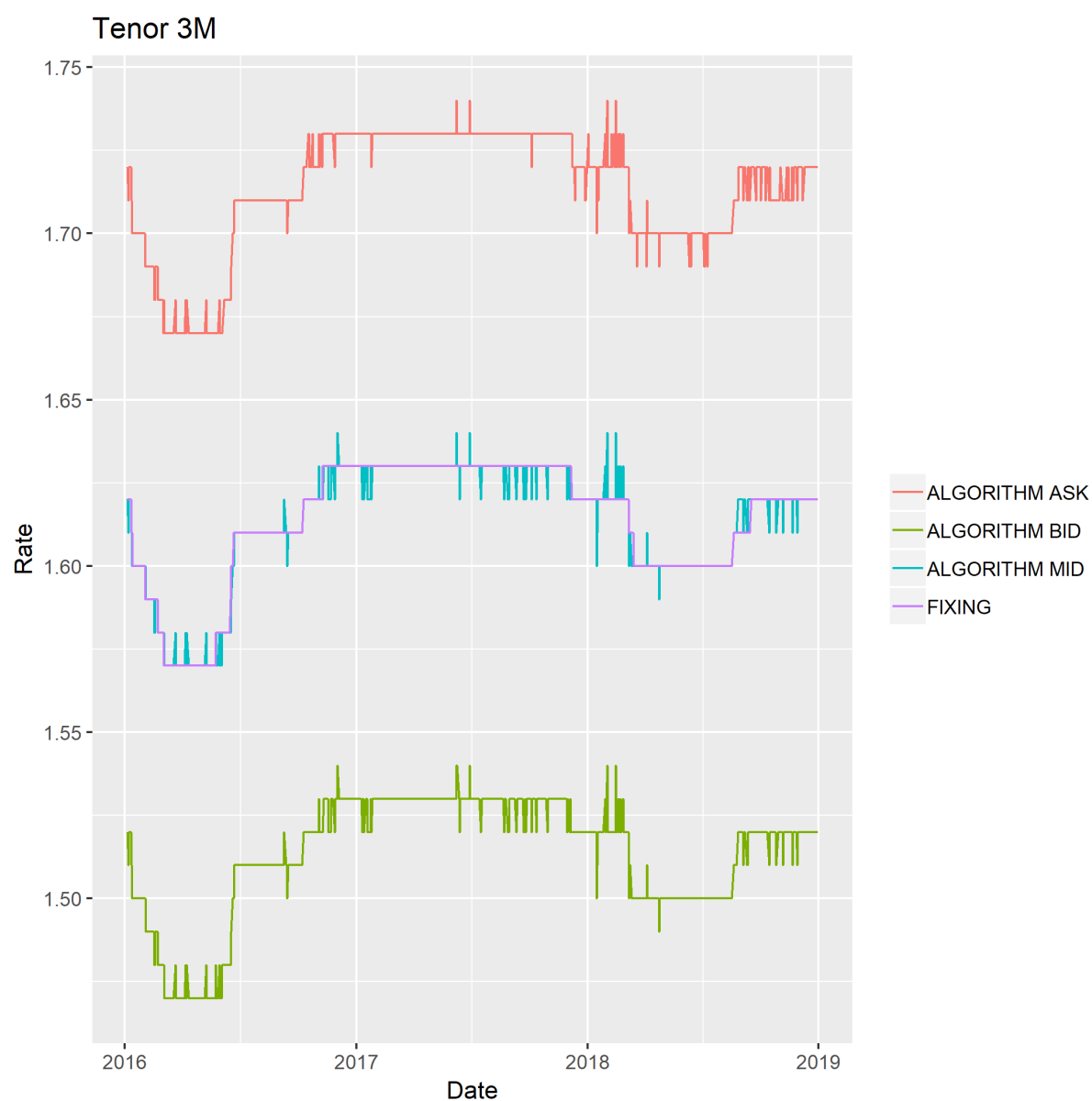


Figure 10. Variant C. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 3M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

7.4 Decrease of the volume eligibility thresholds of Transactions to PLN 0 million (no volume eligibility thresholds)

TENOR/LEVEL	L-1	L-2.1	L-2.2	L-3.1	L-3.2	L-3.3	L-3.4	L-4	TL
ON	90.38%	0.00%	0.00%	6.38%	0.00%	0.29%	0.00%	2.94%	97.06%
TN	13.79%	0.00%	0.00%	7.61%	0.00%	0.00%	0.00%	78.60%	21.40%
SW	2.35%	0.00%	0.89%	0.00%	6.94%	0.00%	9.34%	80.48%	19.52%
2W	1.37%	0.03%	1.44%	8.14%	11.00%	8.30%	9.51%	60.22%	39.78%
1M	1.17%	0.01%	0.61%	15.00%	8.39%	17.61%	5.27%	51.94%	48.06%
3M	0.77%	0.00%	0.13%	4.26%	4.56%	8.05%	9.18%	73.05%	26.95%
6M	0.00%	0.00%	0.00%	0.59%	0.24%	2.30%	1.09%	95.78%	4.22%
1Y	0.31%	0.00%	0.00%	0.40%	0.03%	0.63%	0.01%	98.63%	1.37%

Table 8. Variant D. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols P-1 to P-4 represent the Waterfall Levels. Symbol PT represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.



Figure 11. Variant D. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor ON. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

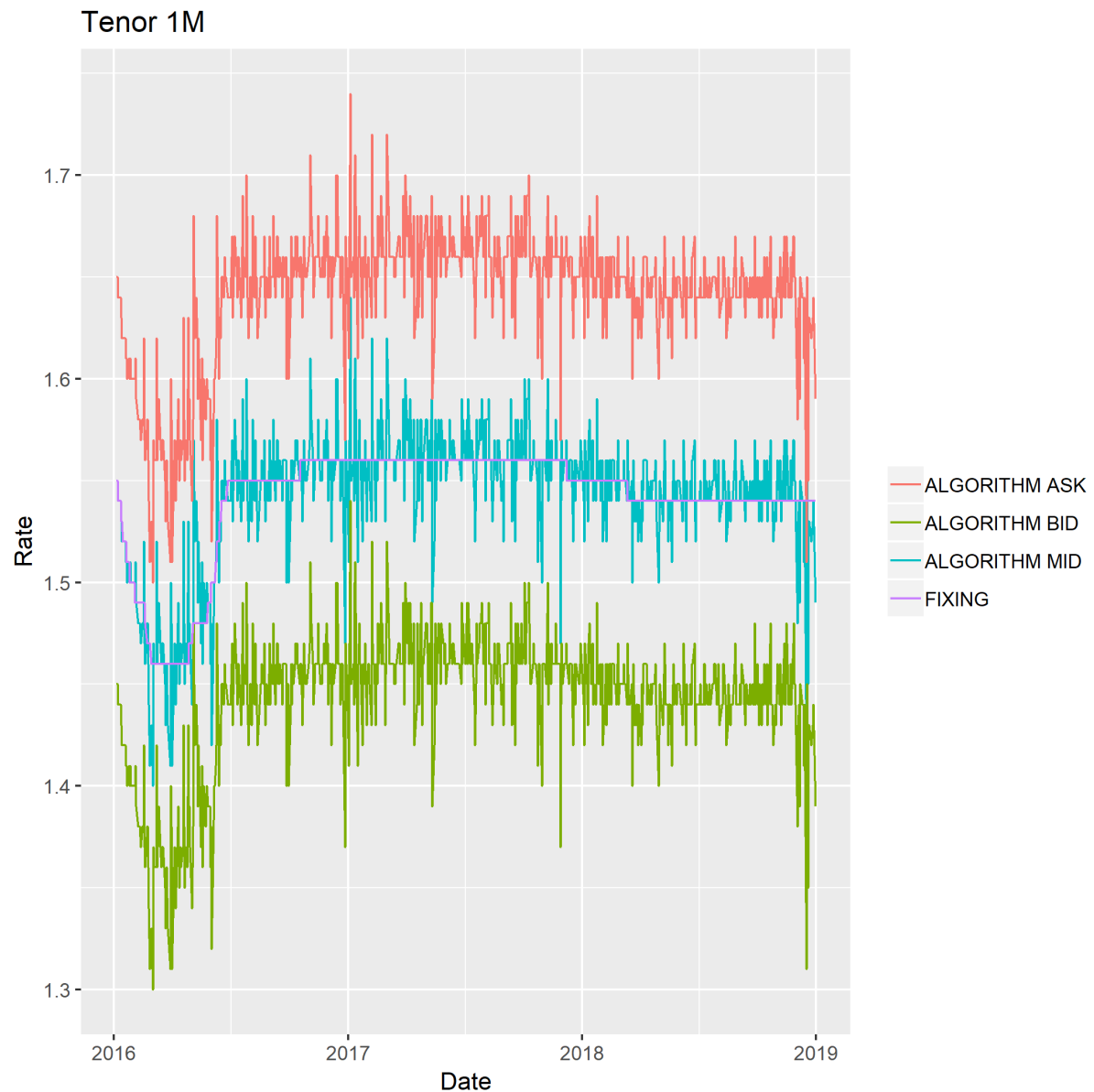


Figure 12. Variant D. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 1M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

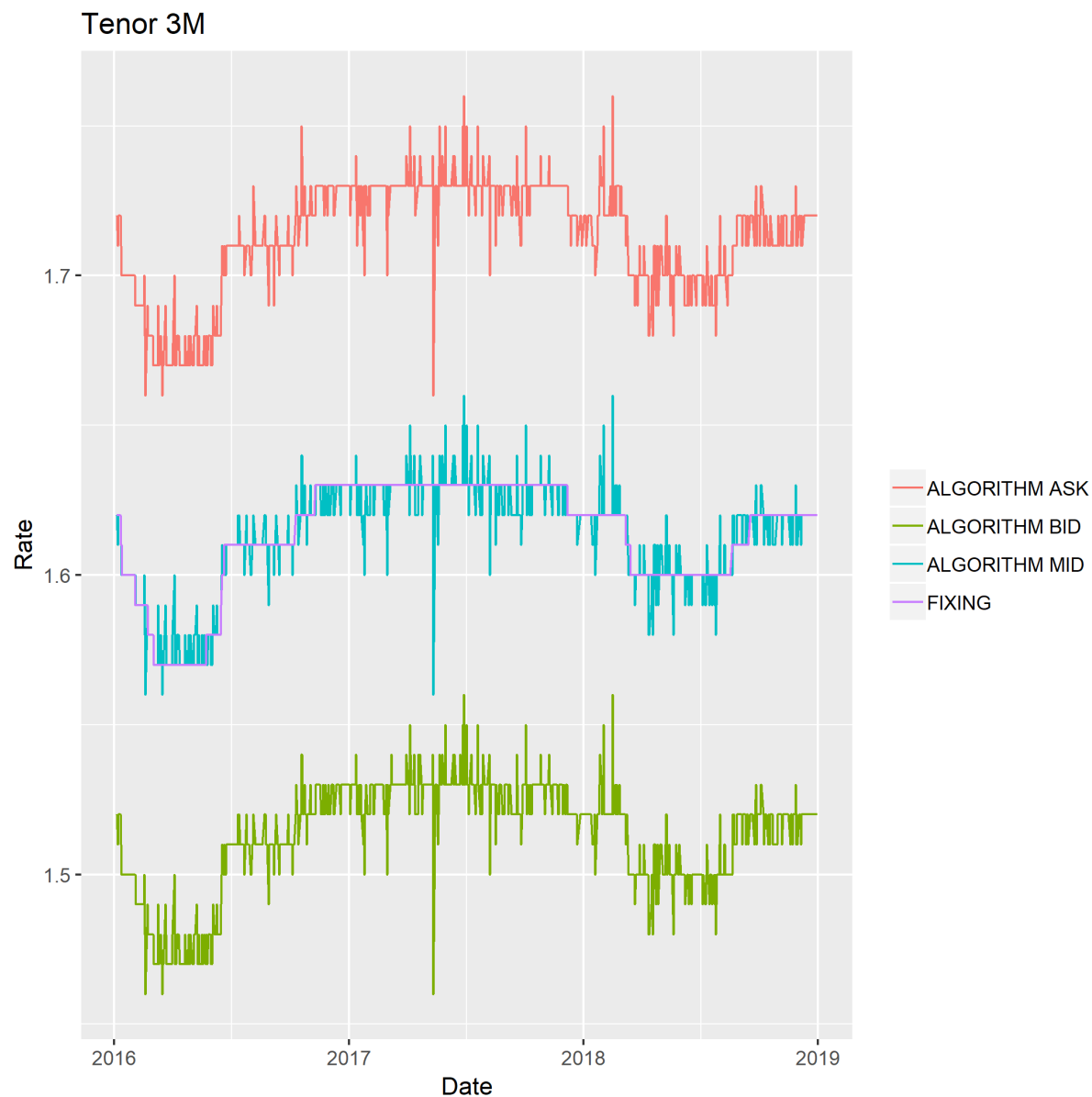


Figure 13. Variant D. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 3M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

7.5 Addition of the Large Enterprises Sector as a related market with a volume eligibility threshold of PLN 2 million

TENOR/LEVEL	L-1	L-2.1	L-2.2	L-3.1	L-3.2	L-3.3	L-3.4	L-3.5	L-3.6	L-4	TL
ON	90.11%	0.00%	0.00%	6.33%	0.00%	0.29%	0.00%	1.52%	0.00%	1.76%	98.24%
TN	13.55%	0.00%	0.00%	7.61%	0.00%	0.00%	0.00%	0.24%	0.00%	78.60%	21.40%
SW	2.33%	0.00%	0.85%	0.00%	5.75%	0.00%	2.83%	0.00%	18.01%	70.24%	29.76%
2W	1.37%	0.03%	1.40%	7.37%	8.91%	1.01%	4.81%	8.63%	16.58%	49.89%	50.11%
1M	1.17%	0.01%	0.61%	10.45%	7.78%	6.96%	6.26%	18.53%	8.64%	39.58%	60.42%
3M	0.77%	0.00%	0.13%	2.30%	3.52%	2.57%	8.91%	12.24%	13.13%	56.43%	43.57%
6M	0.00%	0.00%	0.00%	0.29%	0.11%	0.76%	0.57%	2.54%	4.15%	91.58%	8.42%
1Y	0.31%	0.00%	0.00%	0.19%	0.00%	0.27%	0.01%	0.00%	0.09%	99.14%	0.86%

Table 9. Variant E. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols P-1 to P-4 represent the Waterfall Levels. Symbol PT represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.



Figure 14. Variant E. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor ON. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic mean of arithmetic means of historical values of the Offer and Bid Rates.

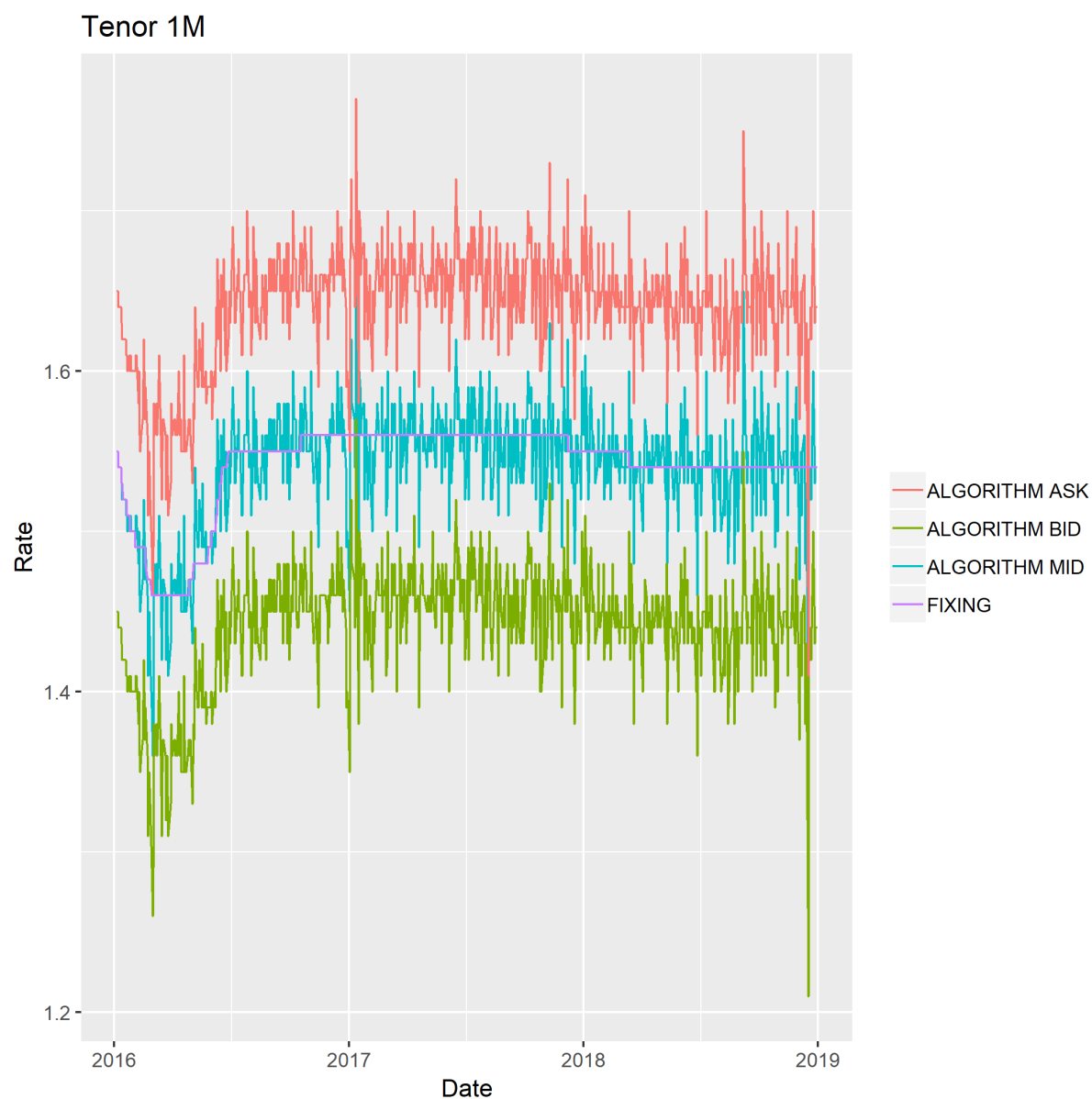


Figure 15. Variant E. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 1M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

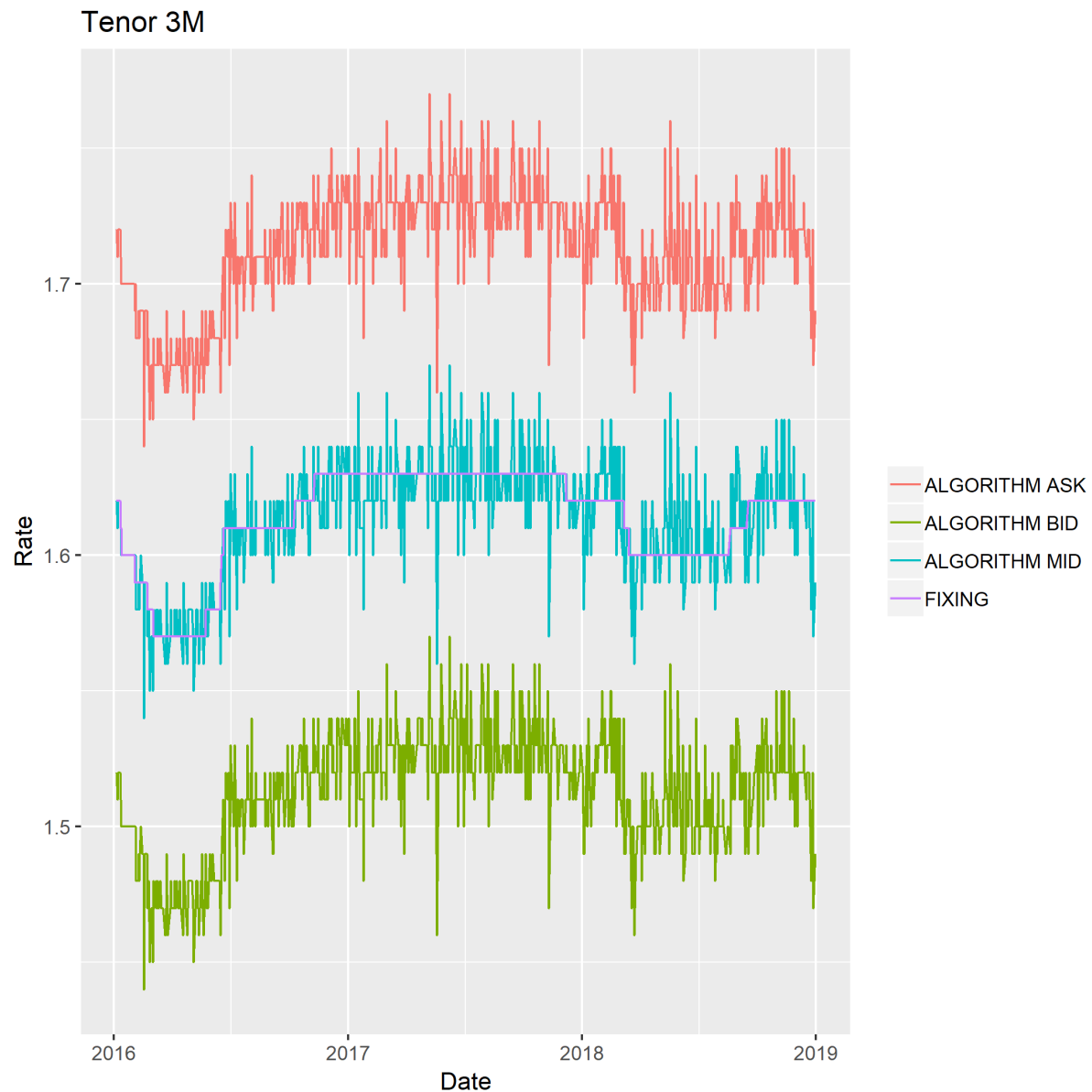


Figure 16. Variant E. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 3M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.

Question 3: Do you support the introduction of transaction eligibility thresholds?

Question 4: In view of the presented results, do you agree with the Baseline Variant parameters as ensuring adequate transactionality at acceptable volatility?

8 MATERIAL CHANGE VERIFICATION METHOD RESULTS

In line with the Administrator's obligations, GPW Benchmark has developed assumptions for the classification of changes to the WIBID/WIBOR Reference Rates calculation method as a material change and for the implementation of material changes to the calculation method.

The key assumption of verification of the Reference Rates calculation method differentiates between the definition of the Reference Rates and the calculation method of the Reference Rates.

As a principle:

- ◆ The definition of an index is a "market or economic conditions to be measured by the index."
- ◆ The method is how the defined market or economic conditions are measured.

8.1 Changes to the Definition of the Reference Rates

According to point 5.1 of the applicable Regulations for WIBID and WIBOR Reference Rates, the Reference Rates are defined as interest rates benchmarks, at which banks meeting the Fixing Participant criteria are ready to place or accept Deposits for specified time periods from other banks meeting the Fixing Participant criteria. It follows from the definition that the market to be measured by the reference rates is a market which meets the following criteria:

- ◆ **Objective Criterion** – The market to be measured by the reference rates is a market in unsecured deposit in the Polish zloty (PLN), accepted or placed on the interbank market.
- ◆ **Subjective Criterion** – Parties to transactions on the market are banks which meet the Fixing Participant criteria.

In the preparation of the proposed Adjustment of the Reference Rates to the BMR, GPW Benchmark did not change the Objective Criterion or the Subjective Criterion of the definition of the Reference Rates. Only the method is to be adjusted. Consequently, GPW Benchmark carried out analyses defining the criteria of a Material Change of the method.

Question 5: Do you agree with the characteristics in the definition of the WIBID and WIBOR Reference Rates?

8.2 Change of the Reference Rates Method

The Reference Rates Method, i.e., the method of calculating a benchmark for the market to be measured by the Reference Rates, is defined in the Regulations for WIBID and WIBOR Reference Rates and the Code of Conduct.

The Key Elements of the Method were identified on the basis of the Reference Rates Regulations:

- The Reference Rates are calculated according to the Fixing procedure which determines the arithmetic mean of Quotes (excluding extreme Quotes).
- Quotes are Input Data provided by Fixing Participants.
- The Reference Rates are calculated at 11:00.
- The Reference Rates are bilateral rates, i.e., the Administrator determines a Bid Rate (a price at which banks may accept Deposits) and an Offer Rate (a price at which banks may place Deposits).

In addition to the key elements of the method, there are a number of specific rules and solutions comprised by the description of the WIBID and WIBOR reference rates calculation method. As a part of the material rules, the Administrator identifies:

- The maturity structure of tenors defined in point 6.1 of the applicable Regulations for WIBID and WIBOR Reference Rates .
- Changes to specific solutions for the preparation of Input Data in the form of Quotes.

Question 6: Do you agree with the classification of the key elements of the WIBID/WIBOR Reference Rates calculation method?

As a part of the review of the materiality of changes to the method, Materiality Criteria were introduced to verify the scale and scope of statistical and economic implications of changes to the key elements of the method, which set the limits beyond which changes to the measurement method of a market or economic conditions is considered a Material Change.

Material Change

The Administrator determines whether a change to a key element of the method causes the Materiality Criteria to be met, classifies the planned change as a Material Change on that basis, and initiates a procedure for the material change of the method. The Administrator may decide to check a material change to a non-key element of the method if there are objectively justified indications that the planned change may be a material change to the characteristics or performance of the index. Changes of market conditions which impact index values are not considered to be indications which require a review of a material change.

8.3 Materiality Criteria

The Administrator applies materiality thresholds to:

- ♦ Material changes of the level of the WIBID and WIBOR Reference Rates. To identify a material change of the level of the WIBID and WIBOR Reference Rates, a statistical test is carried out for each of WIBID and WIBOR rate separately, for each Fixing Tenor separately, in order to verify a hypothesis that the absolute value of the difference between the average value of the model rate in the reference period and the average value of the historical rate in the reference period does not exceed 5 basis points and, if it does exceed 5 basis points, that it does not exceed 2% of the average value of the historical rate in the reference period. If the tested hypothesis is rejected for a given Rate and a given Fixing Tenor, at a significance level of 5%, then the criterion is considered to be met for the Rate in question and the Fixing Tenor in question (i.e., the change is material).
- ♦ Material changes of the performance of the WIBID and WIBOR Reference Rates. To identify a material change of the performance of the WIBID and WIBOR Reference Rates, a statistical test is carried out for each of the WIBID and WIBOR rates separately, for each Fixing Tenor separately, in order to verify a hypothesis that rank correlation between the model rate in the reference period and the historical rate in the reference period is positive (one-tailed test). If the tested hypothesis is rejected for a given Rate and a given Fixing Tenor at a significance level of 5%, then the criterion is considered to be met for the Rate in question and the Fixing Tenor in question (i.e., the change is material).
- ♦ Material increase of the volatility of the WIBID and WIBOR Reference Rates. To identify a material increase of the volatility of the WIBID and WIBOR Reference Rates, a statistical test is carried out for each of the WIBID and WIBOR rates separately, for each Fixing Tenor separately, in order to confirm the hypothesis that the standard deviation of the first differences of the model rate in the reference period is not bigger than the standard deviation the first differences of the historical rate in the reference period by more than 1.5 basis points (one-tailed test) and, if it is bigger by more than 1.5 basis points, that it is not bigger by more than 10% of the standard deviation of the first differences of the historical rate in the reference period (one-tailed test). If the tested hypothesis is rejected for a given Rate and a given Fixing Tenor at a significance level of 5%, then the criterion is considered to be met for the Rate in question and the Fixing Tenor in question (i.e., the change is material).

The test of the fulfilment of the Materiality Criteria is carried out on the basis of data for a period of at least 1 calendar year ending in the year of the test or in the year preceding the year of the test (reference period).

8.4 Verification results

The work on the WIBOR Index identified three areas which GPW Benchmark decided to check in the review of material changes to the WIBID and WIBOR Reference Rates method, including changes to a key element of the method.

The results presented below are a part of the verification of the working hypothesis assuming that the WIBOR Index is, in principle, identical to the WIBID and WIBOR reference rates.

I.

Concerning changes to elements classified as key elements of the method, the Administrator verified changes to the publication timing of WIBOR Index Fixings for tenors ON and TN.

The organisational change to the publication timing of the WIBID/WIBOR Reference Rates in respect of the enforcement of certain solutions and rules for the preparation of Input Data by implementing the Waterfall Method is required in order to ensure a reliable and adequate description of markets and economic conditions.

An analysis based on the Materiality Criteria confirms that none of the Materiality Criteria are met in the Waterfall Method baseline variant (see point III below).

Question 7: Do you agree with the results of the classification of the publication time of tenors ON and TN?

II.

Concerning changes to elements not classified as key elements of the method, the Administrator considered the decision to discontinue the calculation and publication of the WIBOR Index Fixing for tenor 9M to be a change that is not a material change.

The change to the maturity structure follows from GPW Benchmark's surveys of Fixing Participants, who suggested the option of discontinuing the tenor in view of its infrequent use and application in contracts and financial instruments.

Question 8: Do you agree with the results of the classification of the change to the maturity structure due to discontinuation of the provision and publication of tenor 9M?

III.

Concerning changes to elements not classified as key elements of the method, the Administrator considered the decision to implement the Waterfall Method to the extent of specific principles of preparation of Input Data to be a change that is not a material change.

In addition, an analysis based on the Materiality Criteria suggests that the Waterfall Method baseline variant does not cause any of the Materiality Criteria to be met.

Verification of the criterion of Material changes of the level of the WIBID and WIBOR Reference Rates

To verify the criterion of Material changes of the level of the WIBID and WIBOR Reference Rates, a test was carried out for each Fixing Tenor $\tau \in \{ON, TN, SW, 2W, 1M, 3M, 6M, 1Y\}$ for the Bid and Offer Rates, denoted by $S \in \{BID, OFFER\}$ to verify the hypothesis that:

$$\mu_{x,\tau}^S - \mu_{y,\tau}^S \leq \gamma \text{ (Test 1)}$$

as well as a test to verify the hypothesis that:

$$\mu_{x,\tau}^S - \mu_{y,\tau}^S \geq -\gamma \text{ (Test 2)}$$

where $\mu_{x,\tau}^S$ stands for a historical average value of Rate S for Fixing Tenor τ in the period from January to December 2018, $\mu_{y,\tau}^S$ stands for a historical average value of Rate S for Fixing Tenor τ of the WIBOR Index generated in a simulation experiment carried out for the Waterfall Method baseline scenario in the same period, and γ stands for test threshold expressed in basis points. Tables 10 – 11 present the critical probabilities¹⁵ of the Rates and Fixing Tenors. The reported critical probabilities

¹⁵ Critical probability values allow you to report the results of statistical tests performed. Since the significance level adopted in the testing process is 0.05, if the critical probability value is less than 0.05, it is necessary to reject the null hypothesis in favour of the alternative hypothesis for the given test, and if the critical probability value is higher than 0.05, there is no basis for the given test, to add a null hypothesis.

suggest no grounds to reject the null hypothesis for any of the Bid or Offer Rates and any of the Fixing Tenors at a significance level of 5%. This implies that the verified Materiality Criterion is not met for any of the Fixing Tenors and any of the Bid or Offer Rates.

Rate / Tenor	ON	TN	SW	2W	1M	3M	6M	1Y
OFFER	0.74	1	1	1	1	1	1	1
BID	0.77	1	1	1	1	1	1	1

Table 10. Critical probabilities for rates and tenors (Test 1).

Rate / Tenor	ON	TN	SW	2W	1M	3M	6M	1Y
OFFER	1	1	1	1	1	1	1	1
BID	1	1	1	1	1	1	1	1

Table 11. Critical probabilities for rates and tenors (Test 2).

Verification of the criterion of Material changes of the performance of the WIBID and WIBOR Reference Rates

To verify the criterion of Material changes of the performance of the WIBID and WIBOR Reference Rates, a test was carried out for each Fixing Tenor $\tau \in \{ON, TN, SW, 2W, 1M, 3M, 6M, 1Y\}$ for the Bid and Offer Rates, denoted by $S \in \{BID, OFFER\}$ to verify the hypothesis of a zero Kendall's rank correlation between the model rate generated in a simulation experiment carried out for the Waterfall Method baseline scenario in the period from January to December 2018 and the historical rate in the same period, with an alternative of a positive correlation. Table 12 presents the critical probabilities for the Rates and Fixing Tenors. The reported critical probabilities suggest that the null hypothesis is rejected in favour of the alternative hypothesis for all of the Bid or Offer Rates and all of the Fixing Tenors at a significance level of 5%. This implies that the verified Materiality Criterion is not met for any of the Fixing Tenors and any of the Bid or Offer Rates.

Rate / Tenor	ON	TN	SW	2W	1M	3M	6M	1Y
OFFER	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
BID	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 12. Critical probabilities for rates and tenors.

Verification of the criterion of Material increase of the volatility of the WIBID and WIBOR Reference Rates

To verify the criterion of Material increase of the volatility of the WIBID and WIBOR Reference Rates, a test was carried out for each Fixing Tenor $\tau \in \{ON, TN, SW, 2W, 1M, 3M, 6M, 1Y\}$ for the Bid and Offer Rates, denoted by $S \in \{BID, OFFER\}$, to verify the hypothesis that:

$$\sigma_{\Delta y, \tau}^S - \sigma_{\Delta x, \tau}^S \leq \gamma$$

where $\sigma_{\Delta x, \tau}^S$ stands for the standard deviation of the first differences of historical Rate S for Fixing Tenor τ in the period from January to December 2018, $\sigma_{\Delta y, \tau}^S$ is the standard deviation of the first differences of model Rate S for Fixing Tenor τ generated in a simulation experiment carried out for the Waterfall Method baseline scenario in the same period, and γ is the test threshold expressed in basis points. Table 13 presents the critical probabilities for the Rates and Fixing Tenors. The reported critical probabilities suggest no grounds to reject the null hypothesis for any of the Bid or Offer Rates and any of the Fixing Tenors at a significance level of 5%. This implies that the verified Materiality Criterion is not met for any of the Fixing Tenors and any of the Bid or Offer Rates.

Rate / Tenor	ON	TN	SW	2W	1M	3M	6M	1Y
OFFER	0.19	1	1	1	1	1	1	1
BID	0.21	1	1	1	1	1	1	1

Table 13. Critical probabilities for rates and tenors.

Question 9: Do you agree with the results of the classification of the change to the specific principles of preparing Input Data?

Question 10: Do you agree that the results of the Adjustment of WIBID/WIBOR suggest that the key elements of the WIBID/WIBOR Reference Rates method have not changed?

IV.

In addition, the fulfilment of the Materiality Criteria was verified for a Waterfall Method variant where related markets include the Financial Institutions Segment and the Other Financial Institutions Segment as well as the Enterprises Segment limited to large enterprises (Segment ES – L) with a transaction volume threshold at PLN 2 million. The tests were identical with the tests presented in point III above. Tables 14 – 17 present the critical probabilities for the respective tests. The test results suggest that the criterion of Material changes of the level of the WIBID and WIBOR Reference Rates is not met for any of the Bid or Offer Rates and any of the Fixing Tenors. Likewise, the test results suggest that the criterion of Material changes of the performance of the WIBID and WIBOR Reference Rates is not met for any of the Bid or Offer Rates and any of the Fixing Tenors. The test results suggest, however, that the criterion of Material increase of the volatility of the WIBID and WIBOR Reference Rates is met for tenors 2W, 1M and 3M.

Rate / Tenor	ON	TN	SW	2W	1M	3M	6M	1Y
OFFER	0.73	1	1	1	1	1	1	1
BID	0.74	1	1	1	1	1	1	1

Table 14. Critical probabilities for the criterion of Material changes of the level of the WIBID and WIBOR Reference Rates (Test 1).

Rate / Tenor	ON	TN	SW	2W	1M	3M	6M	1Y
OFFER	1	1	1	1	1	1	1	1
BID	1	1	1	1	1	1	1	1

Table 15. Critical probabilities for the criterion of Material changes of the level of the WIBID and WIBOR Reference Rates (Test 2).

Rate / Tenor	ON	TN	SW	2W	1M	3M	6M	1Y
OFFER	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
BID	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 16. Critical probabilities for the criterion of Material changes of the performance of the WIBID and WIBOR Reference Rates.

Rate / Tenor	ON	TN	SW	2W	1M	3M	6M	1Y
OFFER	0.16	1	1	<0.01	<0.01	<0.01	1	1
BID	0.16	0.99	1	<0.01	<0.01	<0.01	1	1

Table 17. Critical probabilities for the criterion of Material increase of the volatility of the WIBID and WIBOR Reference Rates.

9. SUMMARY

The Waterfall Method is a result of the WIBID and WIBOR rate adjustment process carried out by GPW Benchmark. The construction of the Waterfall Method ensures the highest priority of transaction data in the benchmark calculation method, consistent with the BMR input data priority recommendation specified in Annex 1 of the Regulation.

With a range of parameters and elements incorporated into the Waterfall Method, the Administrator of the benchmark has been provided with a comprehensive tool enabling gradual evolution of the WIBID/WIBOR reference rates calculation method in the future.

Not only does the Consultation Paper contain a description of the calculation method but also it presents the results of the Waterfall Method's baseline variant simulation for the WIBID and WIBOR reference rates. From the viewpoint of GPW Benchmark, the baseline variant of the Waterfall Method will ensure optimal implementation of the BMR requirements as far as the benchmark representativeness, stability and continuity are concerned. The statistical tests of simulations based on the Waterfall Method under the baseline variant seem to confirm that there are no grounds to identify material changes of the WIBID and WIBOR reference rates.

GPW Benchmark welcomes any feedback from consultation process participants. Any opinions and suggestions expressed by professional benchmark users during the current consultation procedure will be of great support in the Waterfall Method calibration process. The official consultation process is expected to be completed in the middle of September 2019. However, all the suggestions and comments from interested parties will be considered in the future review of the calculation method which the Administrator is required to perform at least every two years.

GPW Benchmark intends to apply to the Polish Financial Supervision Authority for the authorisation to act as the WIBID and WIBOR Administrator under the BMR Regulation in December 2019.

LIST OF TABLES

Table 1. Similarity metrics of centred distributions of average daily volume-weighted prices in the Segments and in the Reference Market	9
Table 2. Waterfall Levels in the Waterfall Method.....	14
Table 3. Rules of allocation of Fixing Tenors to transactions	15
Table 4. Waterfall Method baseline variant parameters.....	25
Table 5. Variant A. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols L-1 to L-4 represent the Waterfall Levels. Symbol TL represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.	27
Table 6. Variant B. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols P-1 to P-4 represent the Waterfall Levels. Symbol PT represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.	31
Table 7. Variant C. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols P-1 to P-4 represent the Waterfall Levels. Symbol PT represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.	35
Table 8. Variant D. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols P-1 to P-4 represent the Waterfall Levels. Symbol PT represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.	39
Table 9. Variant E. Frequency of use of Waterfall Levels for Transaction Tenors. Symbols P-1 to P-4 represent the Waterfall Levels. Symbol PT represents the transactionality of the Waterfall Method, i.e., the frequency of use of Transaction Data, taking into account the Analytical Procedures.	43
Table 10. Critical probabilities for rates and tenors (Test 1).	50
Table 11. Critical probabilities for rates and tenors (Test 2).	50
Table 12. Critical probabilities for rates and tenors.	50
Table 13. Critical probabilities for rates and tenors.	51
Table 14. Critical probabilities for the criterion of Material changes to WIBID and WIBOR Reference Rates values (Test 1).	51
Table 15. Critical probabilities for the criterion of Material changes to WIBID and WIBOR Reference Rates values (Test 2).	52
Table 16. Critical probabilities for the criterion of Material changes to WIBID and WIBOR Reference Rates performance.	52
Table 17. Critical probabilities for the criterion of Material increase of WIBID and WIBOR Reference Rates volatility.	52

LIST OF FIGURES

model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.	42
Figure 14. Variant E. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor ON. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic mean of arithmetic means of historical values of the Offer and Bid Rates.	44
Figure 15. Variant E. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 1M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.	45
Figure 16. Variant E. Performance of historical and model values of the WIBID and WIBOR Reference Rates from January 2016 to December 2018 for tenor 3M. Symbols: ALGORITHM ASK, ALGORITHM BID – model values of the Offer and Bid Rates; ALGORITHM SR – arithmetic means of model values of the Offer and Bid Rates; FIXING – arithmetic means of historical values of the Offer and Bid Rates.	46