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**RUSSIAN GOVERNMENT BOND (OFZ)**

**ZERO COUPON YIELD CURVE METHODOLOGY**

**MOSCOW EXCHANGE 2021**

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# Terms and definitions

For the purpose of this OFZ Zero Coupon Yield Curve Methodology by Public Joint Stock Company Moscow Exchange MICEX-RTS (the “Methodology”) the following terms and definitions shall apply:

*Curve basis* is the list of government bonds with market data used to calculate the curve.

*Basis point* isa unit of return equal to one hundredth of a percent (1bp = 0.01%)*.*

*Zero coupon yield* is the yield to maturity of a discount bond.

*Exchange* is Public Joint Stock Company Moscow Exchange MICEX-RTS

The *weight* is a parameter calculated algorithmically upon monthly revision of the Curve Basis for each government bond from the Basis.

*The time of price level* is the point in time from which a given price level exists continuously.

*Government bonds (hereinafter also referred to as the "bonds")* are government bonds (OFZ) admitted to trading on the Exchange.

*Settlement date* is the date on which, in accordance with the terms of a trade in a government bond and the Moscow Exchange Trading Rules for the equity & Bond Market (the “Rules”), trading participants and/or the clearing organization are obliged to fulfill their obligations under the trade in the procedure set forth in the internal documents of the clearing organization and/or the Trading Rules.

*Dynamic parameters* are coefficients .

*Trade yield* is the yield to maturity corresponding to the price of a certain trade executed in the Trading Mode "Main Trading Mode T+" of the Equity & Bond Market (the “Main Trading Mode”) and calculated in accordance with the procedure set forth in the Exchange internal documents for the market.

*The Curve* is the zero coupon yield curve for the government bond market, whisch is calculated as set out in this Methodology.

*Adjustment* is an additive to the estimated yield, which specifies the estimated yield of a bond. For reference issues, corrective adjustments are zero.

*The zero coupon yield curve* is the relationship between the zero coupon yield and the term of a discount bond in homogeneous debt obligations; it is a function of the term structure of interest rates.

*Reference issue* is the most liquid bond issue included in the Curve Basis, for which the adjustment is identically zero.

*Estimated price* is the price of a bond calculated based on the Curve as the sum of the payments under that bond as discounted to the settlement date.

*Estimated yield* is the yield to maturity corresponding to the estimated price of the bond.

*Static parameters* are values that are settings of the algorithm, such as , , ÷, , , ,  ÷, , , , , , , , , , , , , , . They are set and changed by the Exchange.

*Adjusted estimated yield* is the sum of the Estimated yield and the Adjustment for that bond.

*Adjusted estimated price* is the net price of a bond at which the yield to maturity equals the adjusted estimated yield.

*Spread* is the difference between the trade yield and the adjusted estimated yield.

*Fixed parameters* are constant values ÷ , ÷ .

*Price levels* is a set of prices for a particular issue of government bonds at any given time, for each of which there is at least one active limit order. All orders submitted with the same price refer to the same price level.

# Overview

* 1. This Methodology establishes the procedure for determining the curve basis, the list of reference issues, static and dynamic parameters, and the procedure for disclosing information about the Curve.
	2. This Methodology as well as amendments and additions hereto shall be developed taking into account recommendations of the Expert Council of the Pricing Center of National Settlement Depository (the “Expert Council”). The Expert Council shall perform the following functions:

### forming an expert opinion, suggestions and recommendations to the Exchange's authorised body regarding the development of the Curve calculated by the Exchange;

### developing proposals for the improvement of the Curve;

### developing recommendations for the disclosure of information about the Curve;

### considering complaints and suggestions from users of the Curve and, if there are valid and substantial complaints, taking measures jointly with the Exchange to develop and implement appropriate changes.

* 1. The business of calculating the Curve and reviewing and updating this Methodology is based on a set of guidelines and requirements described in the Moscow Exchange Index Management Policy.
	2. The zero coupon yield curve for government bonds has the following names:
		1. full name in Russian: "Кривая бескупонной доходности государственных облигаций России";
		2. full name in English: "Russian Government Bond Zero Coupon Yield Curve";
		3. abbreviated name in Russian: "КБД Московской Биржи";
		4. abbreviated name in English: "MOEX GСURVE", "MOEX ZCURVE".
	3. Terms and definitions not set forth in this Methodology shall have the meanings set forth by other internal documents of the Exchange, as well as Russian federal laws and regulations adopted in accordance therewith.

# Procedure for determining the curve basis

* 1. The curve basis is revised monthly. The new curve basis is implemented on the 15th of each month. If that date falls on a non-business day, the curve basis is be implemented on the next business day.
	2. The following bond issues are not considered relevant for the curve basis:
		1. Bonds with a maturity of less than two months as at the 15th day of the month in which the new curve basis comes into effect;
		2. Bonds for which at least one payment (including coupon, amortisation and redemption payments) is not fixed (unknown);
		3. Russian government bonds with debt amortisation.
	3. The list of bonds to be included in the curve basis is determined in the following order.
		1. The bonds are divided into three groups, based on their term to maturity on the 15th day of the month in which the new curve basis comes into effect:
* bonds with a term to maturity of more than two months but not more than two years;
* bonds with a term to maturity of more than two years but not more than 10 years;
* bonds with a term to maturity of more than 10 years.
	+ 1. To determine the new curve basis, trading volumes and the number of trades executed in the main trading mode are taken into account.
		2. The retrospective period for each date the new curve basis takes effect is the three-month period preceding the first day of the month on which the curve basis takes effect. For example, the retrospective period for a curve basis which comes into effect on 15 January is from 1 October to 31 December.
		3. First, trades per bond are sorted in descending order of volume and 5% of the total number of trades are excluded from the beginning of the series.
		4. The relative liquidity of bond issues is analysed separately for each of the three groups. Within the group, a liquidity ratio is calculated for each bond for the retrospective period:

|  |  |  |
| --- | --- | --- |
|   |  |  (1) |
| where:  |  |  |  |  |
|  | - | the number of trades executed in the *kth* issue during the retrospective period, subject to paragraph 3.3.4; |
|  | - | the total volume of trades executed in the *kth* issue during the retrospective period, subject to paragraph 3.3.4; |
|  | - | is the arithmetic average of the number of trades  , i.e. the sum across all issues in the respective group divided by the number of issues in the group; |
|  | - | similarly, the arithmetic average of volumes ; |
| *α, β* | - | weighting coefficients, which are static parameters and satisfy the conditions: , , . |

* + 1. For each of the three groups a threshold value of the liquidity ratio is set. Bond issues with liquidity ratios equal to or exceeding the respective thresholds are included in the curve basis.

For each issue included in the base,  is calculated. For this purpose, all issues from the basis are ranked in descending order of the liquidity ratio and the quantile of the given variation series is defined in order of . *Weight* of each issue is equal to the ratio of the liquidity ratio of that issue to the quantile. If this ratio exceeds 100, then *weight* =100 .

* 1. If a group of bonds with a maturity of more than 2 years but not more than 10 years has no issues with, then the issue from that group with the highest weight is designated as the reference issue.
	2. For each issue included in the basis, the standard deviation of the yield to maturityis calculated. For this purpose, the sequence of yields to maturity trades is considered, where is the number of trades in *the kth* issue during the retrospective period, taking into account clause 3.3.4 above. On the basis of this sequence, a series of fluctuations is formed



where the functionconstrains the variable to static levels and . The standard deviation  is determined for the resulting series of fluctuations.

* 1. Other curve basis, weights and reference issues than defined by clauses 3.3, 3.4 and 3.5 of this Methodology can be approved by decision of the Exchange.

# Parametric Curve model

* 1. The curve is represented (in the form of a continuously accruing interest rate) by a parametric Nelson-Siegel model including correction terms:

,

where the termis counted from the settlement date and expressed in years, - in basis points. The fixed parameters are equal to:

, , , ,

, , ,

where.

* 1. Zero coupon yields in the form of spot yields with annual interest capitalisation are related to continuously accruing yields by the ratio (in basis points):

 

and the discount function is given by the expression:

. 

# Data pre-processing

* 1. When calculating the dynamic parameters of the Curve, data on trades (orders) executed (submitted) in the Main Trading Mode in issues from the curve basis is used.
	2. The dynamic parameter vector and adjustment vector are recalculated as a result of either event:
* Entering an order;
* Withdrawal of an order;
* Execution of a trade.
	1. If the event is the execution of a trade, the recalculation takes place in two steps:
* the trade is processed;
* active order remaining after the trade are processed.
	1. If the trade volume is less than** *,* the trade is accounted for as set out in clause 5.3, but no recalculation of parameters and adjustments takes place. Otherwise, the yield to maturity  is determined at the trade price, where **- number of the issue*, *- number of step of recalculation of and .
	2. When orders are processed, active orders are recorded for each of the issues included in the curve basis. If there are bids in bond , the price  is determined as the highest price level of bids satisfying the conditions:
* the period from the time of creation to the time of recalculation (continuous existence period) is equal to or greater than ** (in seconds);
* the volume of bids equals or exceeds ** (in securities).

If there are no bids for this issue or it is not possible to determine if the conditions on** ,** aremet, then it is deemed that is not available.

* 1. Similarly, the ask price  is defined as the lowest price level of the asks satisfying the conditions:
* the period from the time of creation to the time of recalculation (continuous existence period) is equal to or greater than** ;
* the volume of asks equals or exceeds** .

If there are no asks for this issue or it is not possible to determine with ** and** meeting the conditions, then it is deemed thatis not available.

* 1. Prices and  are adjusted to maturity and .

# Calculation of Curve parameters upon execution of a trade

* 1. Adjustments are dampened for all bonds, excluding reference issues ( for reference issues),

,

where  - is the static parameter, - is the vector of adjustments at the previous recalculation step.

* 1. The following pre-calculations are made for the issue  in which the trade was made.
		1. The estimated price is determined:



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| where:  |  |  |  |  |
|  | - | the value of the discount function (3) for the th payment under the bond, calculated using the parameters ; |
|  | - | the value of the th payment under the bond, expressed as a percentage of the outstanding part of the bond's nominal value; |
|  | - | the number of remaining payments stipulated by the terms and conditions of the bond issue. |

* + 1. The bond's estimated yield and adjusted estimated yield are calculated on the basis of the bond's estimated price .
		2. The vector of partial derivatives of the function at the point is calculated numerically.
	1. The new estimate is calculated component by component :

$$\left.\begin{matrix}x\_{n,j}=α\_{j}x\_{n-1,j}+\frac{h\_{j}γ\_{j}^{2}Δ\_{n}}{Q+Λ+dΔ\_{n}^{2}}, if Δ\_{n}^{2}<\frac{Q+Λ}{d}\\x\_{n,j}=α\_{j}x\_{n-1,j}+\frac{h\_{j}γ\_{j}^{2}}{2\sqrt{\left(Q+Λ\right)d}}sign\left(Δ\_{n}\right), if Δ\_{n}^{2}\geq \frac{Q+Λ}{d}\end{matrix}\right\}$$

where:

- component number;

 - bounded residual (and are defined in section 3.6);

;

 - sign of the spread;

 for;

 or  for depending on whether the issue with the number is being processed or there was a different issue at ;

,

where is the period from the settlement date to the maturity date of the bond in fractions of the year; , , , , , , are the static parameters.

* 1. If , i.e. if the parameter has become less than or equal to 0.3, the calculations in clause 6.3 are cancelled, is set to zero and steps set out in clause 6.3 are applied again. The parameter is then reset to its previous value.

# Calculation of Curve parameters upon orders processing

* 1. Adjustments are dampened for all issues (clause 6.1).
	2. An iterative process is carried out in which the boundaries and , as well as the adjustment vector are not changed, and only the curve parameter vector is recalculated . The initial value . One iteration of recalculation of vector  to vector is as follows.
		1. For each bond for which at least one of the yields , is available, the adjusted estimated yield is calculated as peer clauses 6.2.1 and 6.2.2 with replaced by .

* + 1.  is compared to the boundaries and  (or just to one of them if the other is missing). If

,

then this issue is described by the Curve and adjustments satisfactorily. If the above inequalities are met for all issues, then the iteration cycle ends:

, 

* + 1. If there are issues for which one of the above inequalities is not true, the value of the deviation is recorded. The issue whose deviation as multiplied by *the* issue’s *weight*, is the largest is selected. For this issue, a virtual trade is formed with the yield at, which is derived by indenting from the boundary of either or , depending on which of them had the largest deviation, taking into account *weight*:



or

,

where  is the static parameter.

If the boundary for which the deviation was found is  and there is no for the issue in question, then

.

If the boundary for which deviation was found is , and there is no for that issue, then

.

* + 1. The vector  of partial derivatives of the function at the point is calculated numerically.
		2. The new estimate is calculated component by component:

$\left.\begin{matrix}x\_{j}^{m}=α\_{j}x\_{j}^{m-1}+\frac{h\_{j}γ\_{j}^{2}Δ\_{m}}{Q+Λ+dΔ\_{m}^{2}}, if Δ\_{m}^{2}<\frac{Q+Λ}{d}\\x\_{j}^{m}=α\_{j}x\_{j}^{m-1}+\frac{h\_{j}γ\_{j}^{2}}{2\sqrt{\left(Q+Λ\right)d}}sign\left(Δ\_{m}\right),if Δ\_{m}^{2}\geq \frac{Q+Λ}{d}\end{matrix}\right\}$

where:

- component number;

 - the limited spread (function and are defined in clause 3.4);

;

 - sign of the spread value;

 for;

 or  fordepending on whether the issue with the number is being processed or there was a different issue at ;

,

where is the period from the settlement date to the maturity date of the bond issue in fractions of the year; , , , , , , are the static parameters.

* + 1. If , i.e. if the parameter has become less than or equal to 0.3, the calculations set out in clause 7.2.5 are omitted;is set to zero and calculations set out in clause 7.2.5 are made again. The parameteris then given its previous value.
	1. Each iteration is completed by calculating the accuracy criterion for fitting the curve to the boundaries and  for the vector. The criterion is equal to the sum of the boundary deviations (in absolute value) multiplied by the weights of the issues. The history of the criteria and the corresponding vectorsfor the last iterations is saved, where is the static parameter.
	2. The iteration cycle is terminated by one of the following conditions
		1. The criterion for accuracy is zero (no boundary violations). In this case,

, 

* + 1. The accuracy criterion in each of the most recent iterationsis larger than the criterion in the iteration preceding it. In this case,it is assumed to be equal to the parameter vector in that preceding iteration, and the adjustments for issues other than the reference ones are determined by the formulas:
* if the condition set out in 7.2.2 is met, then for this issue

;

* if  , then .
* if  , then .

The number of iterations has exceeded the static parameter . In this case, the lowest value of the accuracy criterion in the last iterationsis determined. The vectoris assumed to be equal to the parameter vector in the that iteration, and the adjustments are determined according to the formulas in clause 7.4.2

* 1. If the curve basis is changed, the initial values of the adjustment factors for issues that were not in the previous curve basis, are set to zero.
	2. If circumstances occur that may have an adverse impact on the adequacy of the Curve to represent the term structure of interest rates, the Exchange may take any action necessary to ensure the adequacy of the Curve, including excluding the Bonds from the Curve Basis, setting values for the parameters used to calculate the Curve provided for by this Methodology, etc.

# Disclosure

* 1. This Methodology, all amendments and additions to it, as well as the curve basis shall be disclosed on the Exchange official website no later than one working day prior to their effective date, unless otherwise determined by the Exchange.

In addition, current static parameters with the history of their changes, as well as the following values at the close of trading (EOD) for each trading day are made available on the Exchange website:

* Dynamic parameters;
* Values of the function for terms  within 0.25 ÷ 30 years;
* Prices and adjustments for issues in the curve basis.

# Annex 1

**To the Government Bonds Zero Coupon Yield Curve Methodology**

**Static parameter values**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| 0,8 | 0,2 | 0,4 | 0.4 | 0.4 | 0,6 | 15 | 10 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| 50 | 50 | 50 | 0,05 | 30 | 30 | 30 | 30 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| 25 | 25 | 25 | 0 | 0 | 0,123 | 150 | 2 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| 10 | 25 | 2 | 20 | 10 | 10 | 0,999 | 20 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| 0,9 | 20 | 150 |  |  |  |  |  |