KAZAKHSTAN STOCK EXCHANGE JSC

A p p r o v e d

by a decision of the Board of Directors of
Kazakhstan Stock Exchange JSC

(minutes No. 44 of the meeting
on September 16, 2019)

Effective

from September 30, 2019

M E T H O D O L O G Y

of determining the yield function of government securities of the Republic of Kazakhstan

Almaty

2019

LIST OF AMENDMENTS

1. **Changes and Additions No. 1:**

   – approved by Kazakhstan Stock Exchange Board of Directors decision (minutes No. 13 of April 14, 2022);

   – effective from April 15, 2022.

2. **Additions No. 2:**

   – approved by Kazakhstan Stock Exchange Board of Directors decision (minutes No. 17 of June 29, 2023);

   – effective from June 30, 2023.

This Methodology establishes the procedure for determining the yield function of non-indexed government securities of the Republic of Kazakhstan, denominated in tenge and issued in accordance with the laws of the Republic of Kazakhstan, the issuers of which are the National Bank of the Republic of Kazakhstan and the Ministry of Finance of the Republic of Kazakhstan, for purposes of:

1) determining the values of the yield on government securities for calculating their market prices;

2) determining risk parameters on financial instruments in order for the Exchange to carry out clearing activities on transactions with financial instruments;

3) for other purposes stipulated by the internal documents of the Exchange.

Article 1. Main concepts and designations

1. Designations and concepts used in this Methodology mean the following:

   1) **GS** – non-indexed government securities of the Republic of Kazakhstan, the issuers of which are the National Bank of the Republic of Kazakhstan and the Ministry of Finance of the Republic of Kazakhstan;

   2) **GS curve (Y(t))** – function of yield of non-indexed government securities of the Republic of Kazakhstan, which is determined in accordance with this Methodology *(this sub-item was changed by a decision of the Exchange's Board of Directors dated 14 April of 2022)*;

   3) **representative selection** – selection of transactions in GS, the parameters of which are used to form the GS curve;

   4) **the Committee on market risks** – a collegial body of the Exchange's Management Board, set up by a decision of the Exchange's Management Board, whose task is to analyze, monitor, identify and manage risks associated with the situation in the financial markets, the procedure for the formation and implementation of activities of which is determined by the Exchange's internal document "Regulation on the Committee on Market Risks"[1].

2. Other terms and concepts used in this Methodology are identical to the terms and concepts defined by other internal documents of the Exchange.

3. Changes and/or additions to this Methodology shall be posted (published) on the Internet resource of Exchange at least three calendar days before the date of introduction of these changes and/or additions, except for changes and/or additions that have editorial and /or clarifying nature and do not affect the procedure for determining the GS curve (Y(t)) *(this item was included by a decision of the Exchange's Board of Directors dated 29 June of 2023).*

Article 2. General provisions on the procedure of forming the GS curve

1. For purposes of forming the GS curve:

   1) deals with GS, which are concluded on the Exchange, are taken into account, including transactions concluded during specialized trades held by the Exchange;

   2) transactions on offering of notes of the National Bank are taken into account, provided that the Exchange has information about such offering as of 18:00 o'clock, Nur-Sultan time, of the day preceding the day of the formation of the GS curve;

   3) trades related to repo transactions are not taken into account;

---

[1] Approved by a decision of Kazakhstan Stock Exchange JSC (minutes No. 97 of the meeting on October 4, 2017).

4) no account is taken of transactions in GS, the maturity of which as of the date of the transaction is less than eight calendar days.

2. The formation of the GS curve is carried out every working day as of 9:00 o'clock, Nur-Sultan time.

3. Parameters for the formation of GS curve and the values of the function Y(t) in the range of 0.25÷30 years are published on the Exchange website daily on weekdays no later than 10.00 a.m. Nur-Sultan time *(this item was changed by a decision of the Exchange's Board of Directors dated 14 April of 2022)*.

4. In order to form the GS curve, the following mathematical functions and quantities are used:

1) instant forward rate F (m) – unobservable continuous function of the bond yield, each point of which corresponds to the forward rate over a period of time tending to zero:

$$F(m) = \frac{-Z'(m)}{Z(m)}, \text{ where:}$$

m – term to redemption in days

Z(m) – zero-coupon rate of return on a bond with maturity m;

2) zero-coupon yield – the yield corresponding to the yield of zero-coupon government securities with maturity m; the relationship between the zero coupon rate Z(m) and the instant forward rate F(m) has the following form:

$$Z(m) = \frac{1}{m} \int_0^m F(u) du$$

3) discount rate – an aggregated presentation of discount factors at each point on the curve; for each urgency m the value of D(m) depends on the rate Z(m):

D(m)=exp(-m*Z(m)), where:

D(m) – discount rate of the bond with maturity m;

4) the yield of pairs or the yield of securities at par – a reflection of the yield of hypothetical securities traded at par; this representation of the curve has the following relationship with the discount rate D(m):

$$Par(m) = \frac{1-D(m)}{\int_0^m D(u) du}$$

5. For purposes of calculating the yield rate in annual terms, continuous rates (r) are converted to annual (R) expression, taking into account the following formula:

$$\exp(r) = 1 + R$$

6. The parametric Nelson-Siegel model, on the basis of which the GS curve is formed, is characterized by three forms of describing the yield curve:

1) function of the instant forward rate:

$$F(m,b) = \beta_0 + \beta_1 \exp\left(-\frac{m}{\tau}\right) + \beta_2 \frac{m}{\tau} \exp\left(-\frac{m}{\tau}\right)$$

2) spot function:

$$Z(m,b) = \beta_0 + \left(\beta_1 + \beta_2\right) \frac{\tau}{m}\left[1 - \exp\left(-\frac{m}{\tau}\right)\right] - \beta_2 \exp\left(-\frac{m}{\tau}\right), \text{ where}$$

$\beta_0, \beta_1, \beta_2, \tau$ – parameters of the Nelson-Siegel model.

3) the function of nominal yield $Par(m)$,, which is defined as the solution of the equation in relation to $Par(m)$ to the estimated discount curve $D(m)$ or to the estimated spot curve $Z(m)$:

$$1 = Par(m) \int_0^m D(s) ds + D(m)$$

$$1 = Par(m) \int_0^m \exp(-s \cdot Z(s))\, ds + \exp(-m \cdot Z(m))$$

7. In order to determine the yield function of GS with annual interest accrual the following formula is used:

$$Y(t) = 100 \times \left[\exp\left(\frac{Z(m,b)}{100} \right) - 1 \right],$$

where:

Z(m, b) - the function of zero-coupon yield in the form of continuously accrued interest with parameters b={b0,b1,b2,τ} of the Nelson-Siegel model with maturity ranges m as defined by the Methodology.

(This item was included by a decision of the Exchange's Board of Directors dated 14 April of 2022)

Article 3.   Determining maturity ranges

1. In order to form the GS curve, the transactions used for its formation are divided into groups called maturity ranges, depending on the maturity of the securities that are the subjects of these transactions.

2. During the first calendar quarter of this Methodology, four maturity ranges are in effect for the formation of the GS curve:

   from 7 to 190 days,

   from 191 to 370 days,

   from 371 to 1825 days,

   from 1825 days and more.

   Starting from the second calendar quarter of this Methodology, the number of maturity ranges and their boundaries are determined by the Committee on market risks once a quarter no later than five business days preceding the first day of the next calendar quarter.

3. The determining of maturity ranges is carried out by the Committee on market risks based on retrospective calculations and forecast data prepared by the Department of information and statistics.

4. The number of maturity ranges and their boundaries determined in accordance with this article are valid during the calendar quarter before the beginning of which they were determined. Information on the number of maturity ranges and their boundaries is published on the Exchange's website prior to their application.

Article 4.   Determining representatives selections

1. Determining a representative selection for each maturity range is carried out from the number of transactions specified in item 1 of Article 2 of this Methodology.

2. The representative selection for each maturity range includes ten last transactions concluded in GS, the current maturity of which at the time of the transaction corresponds to this maturity range, or all transactions in GS, the current maturity of which corresponds to this maturity range, concluded during the trading day, which preceded the day of formation of the GS curve, if there are more than ten of such transactions (taking into account the specifics and restrictions established by this article and article 7 of this Methodology).

3. If the liquidity of GS with current maturity corresponding to a certain maturity range decreases, the Committee on market risks has the right to limit the time period for which transactions are selected for a representative selection of this maturity range, even if in this case the representative selection consists of less than ten transactions.

4. During the first calendar quarter of validity of this Methodology, transactions concluded on the secondary GS market are excluded from the representative selection for the maturity range from 7 to 190 days. In the future, the Committee on market risks has the right to exclude any transactions from representative selections or cancel previously established exceptions in accordance with article 7 of this methodology.

5. When forming representative selections, the aggregation of yield on transactions concluded with the same GS issue is carried out according to the following formula:

$$Y = \frac{\sum_{i=1}^{n}(v_i \times y_i)}{\sum_{i=1}^{n} v_i} \text{ , where:}$$

Y – weighted average yield of GS of one issue in percent per annum;

n – number of transactions with GS of one issue;

V_i – amount of the i-th transaction in tenge;

Y_i – GS's yield to maturity for buyer on the i-th transaction.

6. For each maturity range, the weight of each transaction is calculated depending on the number of days that have passed since the conclusion of this transaction until the date of the formation of the GS curve (ai):

$$w_i = \frac{1}{4} \frac{q^{-a_i/\hat{a}} * \ln v_i}{\sum_{i=1}^{n_s} q^{-a_i/\hat{a}} * \ln v_i} \text{ , where:}$$

I - serial number of the GS trade in the maturity range *(this paragraph was changed by a decision of the Exchange's Board of Directors dated 14 April of 2022)*;

$\ln v_i$ – logarithm of the value of the nominal volume of the i-th transaction;

ai - number of days from the date of conclusion of the i-th trade to the date of formation of the GS curve (on the date of formation of the curve, trades concluded on that day are taken into account) *(this paragraph was changed by a decision of the Exchange's Board of Directors dated 14 April of 2022)*;

$\hat{a}$ – maximum value of ai;

n_s – number of deals within the maturity range *s*;

q – minimum number of deals within the considered maturity range.

7. When forming a representative selection in order to exclude the influence of one-time transactions on the GS curve, the Exchange has the right to exclude for each of the maturity ranges the transactions that meet the following condition:

$$|M_i| > 3.5:$$

$$\text{modified z-score}_{si} = \frac{0.6475*(y_{si}-par(m_{si}, b_{t-1}))}{MAD} \text{ ,}$$

$$MAD_s = median(|y_{si}-par(m_{si}, b_{t-1})|) \text{ (12), where:}$$

M_i - modified z-score$_{si}$ (modified z statistics)

s – maturity range;

i – deals with GS;

m_i – current maturity on deal i;

b_{t-1} – parameters of the curve for the previous date;

y_{si} – value of the yield of deal i in the maturity range s;

MAD_s– median absolute deviation of yields from the curve for the previous period;

n_s – number of deals in the maturity range s.

Article 5.   **Determining parameters for building the GS curve**

1. To form the yield curve and determine its parameters, a set of values of the parameter τ_i looks as $\tau_i \in [0,076;5]$.

2. To construct the GS curve, the method of finding parameters $(\beta_0, \beta_1, \beta_2, \tau)$ based on the Nelson-Siegel model is used, which provide the best value of the matching criterion, subject to the restrictions specified in item 3 of this article.

3. The weighted sum of squares of deviations between the model yield to maturity of government securities according to the Nelson-Siegel model and the actual yield to maturity on each transaction from the total number of transactions in the representative selection is used as the matching criterion:

$$\text{argmin}_\beta \sum_i \left(Y(i,\beta)\text{-}y_i\right)^2 * w_i$$

in this case, the following restrictions are imposed on the parameters:

$$\beta_0 + \beta_1 = \text{TONIA}$$
$$\beta_0 > 0, \text{ where:}$$

w – weight vector;

y – vector of yields to maturity on transactions of the representative selection (corresponding to actual dirty prices);

Y(i) – vector of estimated yields to maturity according to the GS curve specified by the parameters b, while the dimension of the vectors is equal to the selection size.

4. To find the global minimum, the search for the optimal parameters $(\beta_0, \beta_1, \beta_2, \tau)$ is performed in several stages:

    1) a lattice of possible values of the parameter $\tau_i \in [0,076; 5]$; is formed

    2) for each τ_i by way of optimization the problem of finding the optimal parameters $\beta_{0i}, \beta_{1i} \beta_{2i}$ is solved;

    3) from the set of parameters $b_i = (\beta_{0i}, \beta_{1i}, \beta_{2i}, \tau_i)$ the b_i is selected that minimizes the compliance criterion specified in item 3 of this article.

Article 6.   **Determining the estimated yield of GS**

1. The estimated yield of each government security is determined in accordance with the following formula:

$$p_i \equiv \sum_{j=1}^{T_i} C_{ij} \cdot \exp(-y_i \cdot m_{ij}) = N_i \cdot \exp(-y_i \cdot m_{iTi}) + \sum_{j=1}^{T_i} cpn_i \cdot \exp(-y_i \cdot m_{iTi}) \quad,$$
where:

y_i – yield to maturity on transaction i corresponding to the actual dirty price of the transaction;

j – serial number of the future flow of payments on GS at the time of the transaction i; the flow of payments on the security includes both coupons and principal debt (par value); for zero-coupon (discount) bonds, the flow of payments consists of one payment (par value);

T_i – the number of payment streams remaining at the time of transaction i, including the payment of the principal;

m_{ij} – the remaining period to payment for stream j at the time of transaction i in years;

C_{ij} – amount of payment on flow j of the bond being the subject of the transaction i;

cpn_i – coupon rate of GS, which is the subject of the transaction i;

N_i – face value of the GS being the subject of the transaction i.

2. The settlement price for each government securities is determined in accordance with the following formula::

$$P(i,b)=\sum_{j=1}^{T_i} C_{ij} \cdot D(m_{ij},b) = \sum_{j=1}^{T_i} cpn_i \cdot D(m_{ij},b)+N_i \cdot D(m_{iT_i},b), \text{ where:}$$

$P(i,b)$ is determined depending on the flow of payments on the GS at the time of the transaction i and the parameters of the yield curve, which determine the discount rate for each flow of payments on GS.

3. The yield to maturity $Y(i,b)$ estimated according to the model, depends on the flow of payments on the GS of transaction i and the parameters of the yield curve, which determine the discount rate for each flow of payments on the GS. The yield to maturity is found by solving the following equation:

$$P(i,b_n)=\sum_{j=1}^{T_i} C_{ij} \cdot \exp(- Y(i,b)\cdot m_{ij})$$

Article 7. **Special powers of the Committee on market risks**

1. In situations where, in the opinion of the Committee on market risks, the type of the GS curve built according to the function determined in accordance with this Methodology, does not reflect the objective situation on the GS market due to the lack of representativeness or insufficient data required to form the GS curve, the Committee on market risks has the right to:

   1) carry out an extraordinary building of the GS curve in accordance with this Methodology;

   2) change the list of parameters established by this Methodology used to build the GS curve;

   3) carry out an extraordinary revision of the parameters established by Article 3 of this Methodology;

   4) take any other actions that, in the opinion of the Committee on market risks, are necessary to build a representative GS curve.

2. When the Committee on market risks uses its special powers established by this article, the minutes of its meetings must reflect the reasons for using these powers and the actions taken in accordance with these powers, as well as the validity period of the GS curve built with the use of these powers.

Article 8. **Final provisions**

1. Responsibility for the timely making of changes and/or additions (updating) to this Methodology rests with the Department of information and statistics.

2. This Methodology is subject to updating as necessary, but at least once every three years.

Chairperson of the Management Board   A. Aldambergen