

Republic of Armenia Treasury bond yield curve construction regulation

A. The purpose, the method and main concepts

1. The purpose of this regulation is to present insight into construction of spot and yield-to-maturity curves of the Republic of Armenia treasury securities and Central Bank of Armenia bills issued in local currency (Armenian Dram).

2. The main concepts used are as follows:

RA –the Republic of Armenia;

CBA – the Central Bank of the RA;

Bond – treasury coupon bond, issued by the RA, with semi-annual coupon payments and ACT/ACT convention except for principal amortizing bonds, savings bonds and strips;

Bill –treasury bill, issued by the RA or the CBA, with up to 1 year maturity, annual compounding and ACT/360 convention;

Government bond – Bonds and Bills;

Maturity – the remaining time till the maturity date of the Bond/Bill;

Stock exchange – the “Nasdaq OMX Armenia” JSC’s;

Benchmark bond – a Bond defined as a benchmark by the RA Ministry of Finance;

Input data – the data used for optimization of the Nelson-Siegel model as provided in section “D” of this document;

Secondary market transactions – all Government bond transactions on the Stock exchange and over-the-counter market;

Hypothetical coupon bonds – an assumed bond with semi-annual coupon compounding and ACT/ACT convention entitled with the same maturity and price of a bill;

Coupon period – the number of actual days from the previous coupon payment date (issue date in case of the first coupon) to the next coupon payment date (redemption date in case of the last coupon) with ACT/ACT convention;

Arithmetic rounding rule – an arithmetic operation that allows the numeric value be shown in a certain accuracy of decimal places after the comma. According to the rule the number to be rounded does not change, if the first digit right to that number is less than 5, and increases by 1, if the first digit right to that number is equal or higher than 5;

Other concepts – those defined by other CBA procedures, regulations and documents.

B. Government bond market data used for Input data calculation

3. The data used for the construction of Treasury bond yield curves are:

3.1 average yields of bid and ask quotes of the Benchmark bonds quoted at the stock exchange trading session, according to the Regulation 5/03 “Reporting by the Regulated Market Operator to the Central Bank of Armenia, presenting format and dates” (CBA Board decision # 356-N, dated 16, 2008);

3.2 Secondary market Bond transaction yields with Maturity of 366 days and more;

3.3 Secondary market Bill transaction prices;

3.4 Bills primary placements weighted average yields.

4. The data that do not meet the constraints set out in Appendix 1 as well as Secondary market transactions, which based on expert judgements are outliers, are not included in the yield curve construction. Specifically, data not included in the calculation are:

4.1 Data of Secondary market transactions with a nominal value less than the amount set out in Appendix 1;

4.2 Data of Secondary market Benchmark bond transactions with yield-to-maturities that deviate from the same bond’s average bid and ask quotations in the stock exchange more than the amount set out in Appendix 1;

4.3 Data of Secondary market transactions with non-Benchmark bonds, the yield-to-maturities of which deviate from the linearly interpolated/extrapolated yield levels of the quoted peer benchmark bonds with corresponding maturities more than the limit set out in Appendix 1;

4.4 Data of the RA Ministry of Finance buybacks.

C. Input data calculation

5. Input data for the yield curve construction are calculated from the data described in paragraphs 3 and 4.

6. For the construction of the up to 365 days interval of the yield curve (hereinafter, short end of the curve), the market data on Bills are broken down into three intervals, i.e. up to 91 days, 92 to 182 days and 183 to 365 days. For each interval, at least one Input data is required.

7. To calculate Input data for the short end of the yield curve, for each of the intervals the following data as of the previous business day are used:

7.1 Bills primary placements weighted average yields with corresponding maturities of each of the intervals specified in paragraph 6 of this document;

7.2 Secondary market Bill transaction yields with corresponding maturities of each of the interval specified in paragraph 6 of this document. Yields are calculated based on prices of secondary market transactions, Maturities, and ACT/360 convention;

7.3 If the maturity date of the Bill is a non-business day according to the RA Law “On Holidays and memorial days in the Republic of Armenia”, or is a non-business day according to the RA Government decree “On shifting of the working days”, maturity date is replaced by the redemption date;

7.4 The median of the yields is calculated on Bill transactions in the secondary market and/or primary placement implemented on the same day:

7.4.1 In case of absence of data in any of the intervals specified in paragraph 6 of this document Input data of the closest business day within a time range specified in Appendix 1 is used;

7.4.2 In case of data absence within business days specified in Appendix 1, the missing data of the interval is filled out using an expert assessment provided by the CBA Monetary Policy Operations Unit of the Financial Department.

8. Data calculated in clause 7.4 of this document are converted to bond equivalent yield-to-maturities of Coupon bonds with the same maturities, semi-annual compounding and ACT/ACT convention:

8.1 The bond equivalent yield-to-maturities are calculated as follows:

a) Bill price and yield-to-maturity (with annual compounding and ACT/360 convention);

$$P = \frac{100}{1 + y \times \frac{t}{36000}} \quad (1)$$

b) Bill price and bond equivalent yield (with semi-annually compounding and ACT/ACT convention);

- for bonds with up to 182 days maturity:

$$y_{bey} = \left(\frac{100 - P}{P} \right) \times \frac{200 \times E}{DSC} \quad (2)$$

- for bonds with 183 days and longer maturity:

$$y_{bey} = \left(\left(\frac{100}{P} \right)^{\frac{1}{N-1+\frac{DSC}{E}}} - 1 \right) \times 200 \quad (3)$$

where:

<i>y</i>	Bill yield-to-maturity
<i>t</i>	Actual number of days till Maturity of the Bill
<i>y_{bey}</i>	Bond equivalent yield-to-maturity
<i>DSC</i>	Number of actual days from the settlement date to the next coupon payment date of the Hypothetical coupon bond
<i>E</i>	Hypothetical coupon bond's Coupon period
<i>N</i>	Number of coupons of the Hypothetical coupon bond as of the settlement date

9. For more than 366 days maturities yield curve (hereinafter, long end of the curve) is constructed using Stock exchange Benchmark bonds quotations as well as Secondary market Bond transaction yield-to-maturities as of the previous date.

10. Stock exchange Benchmark bond bid/ask quotes are considered as the main Input data to construct the long end of the curve.

11. Input data for the construction of the long end of the curve are:

11.1 the median of Stock exchange Benchmark bond average bid/ask yield-to-maturities (as referred to in clause 3.1 of this document) and the same Benchmark Bond yield-to-maturities on the Secondary market transactions;

11.2 The last available data of a benchmark bond for yield curve construction are accepted as Input data in case of absence of Stock exchange bid/ask quotations;

11.3 The median of the same non-benchmark Bonds yield-to-maturities on Secondary market transactions;

11.4 The median of yield-to-maturities of the same maturity Bonds Secondary market transactions; the features of the bond with the latest issuance and the median coupon are considered.

D. Construction of Nelson-Siegel model-approximated curves

12. Using Input data, $z(\tau)$ spot interest rates (approximated spots) for τ maturities are calculated based on Nelson-Siegel model:

12.1 The Nelson-Siegel model is as follows:

$$z(\tau) = \beta_1 + \beta_2 \times \frac{1 - e^{-\lambda \times \tau}}{\lambda \times \tau} + \beta_3 \times \left(\frac{1 - e^{-\lambda \times \tau}}{\lambda \times \tau} - e^{-\lambda \times \tau} \right) \quad (4)$$

where:

coefficients $\beta_1, \beta_2, \beta_3$ are economically characterized as long-term factor or level, short-term factor or slope and medium-term factor or curvature parameters, respectively;

12.2 The nonlinear least squared errors method is used to estimate the model parameters:

$$\min_{\Omega} \sum \omega_i \times \varepsilon_i^2 \quad (5)$$

where:

$$\Omega = \{\beta_1, \beta_2, \beta_3, \lambda\}, \quad \omega_i = \frac{1}{Dur_i} \Bigg/ \sum \frac{1}{Dur_i}, \quad \varepsilon_i = P_{Actual} - P_{NS} \quad (6)$$

where:

ε_i is the difference between prices (P_{NS}) obtained by the Nelson-Siegel model and actual prices (P_{Actual}), Dur_i is the duration of each Bond. The inequalities $\beta_1 > 0$, $\beta_1 + \beta_2 > 0$, $\lambda > 0$ are the constraints, which ensure that the long-term and short-term interest rates are positive.

13. The approximated yield-to-maturity values for respective maturities Input data bonds are calculated using the approximated spots as follows:

13.1 Based on the approximated spot curve, a price for each Bond is calculated as follows:

$$DP = \frac{C}{2} \sum_{i=1}^N \frac{1}{\left(1 + \frac{s_{i-1+\tau}}{200}\right)^{i-1+\tau}} + \frac{100}{\left(1 + \frac{s_{N-1+\tau}}{200}\right)^{N-1+\tau}} \quad (7)$$

13.2 Using the price, calculated by approximated spots in the previous step, the approximated yield to maturity is calculated for each bond as follows:

$$DP = \frac{C}{2} \sum_{i=1}^N \frac{1}{\left(1 + \frac{Y}{200}\right)^{i-1+\tau}} + \frac{100}{\left(1 + \frac{Y}{200}\right)^{N-1+\tau}} \quad (8)$$

where:

$$\tau = \frac{DSC}{E} \quad (9)$$

DP	Dirty price for par value of 100
C	Annual coupon for par value
Y	Semi-annually compounding yield to maturity
s	Semi-annually compounding spot rate
DSC	Actual number of days from the settlement date to the next coupon date
E	Coupon period
N	Number of coupon payments due

14. The yield curve of the Bonds is constructed as follows:

14.1 Approximated spots and yield-to-maturities with respective tenors of Input data are linearly interpolated/extrapolated to calculate spot rates and yield-to-maturities for respective tenors specified in clause 16.1 of this document;

14.2 The interpolated/extrapolated interest rates are calculated with the following formula:

$$r_t = r_{t_i} + \frac{t - t_i}{t_{i+1} - t_i} \times (r_{t_{i+1}} - r_{t_i}) \quad (10)$$

where:

t	Tenor, expressed in years, for the interest rate to be calculated
t_i	The closest tenor (previous tenor in case of extrapolation), which is less than the tenor to be calculated, and for which interest rate is known
t_{i+1}	The closest tenor, which is greater than the tenor to be calculated (the closest smaller tenor in case of extrapolation), and for which the interest rate is known
r_t	Interest rate to be calculated
$r_{t_{i+1}}, r_{t_i}$	Known interest rates
$i, i + 1$	Tenors that are respectively smaller and larger from the tenor of the interest rate to be calculated

14.3 Bond maturities in years are calculated with ACT/ACT convention, using the following formula:

$$t = \frac{(N - 1) + \frac{D3M3Y3 - D2M2Y2}{D3M3Y3 - D1M1Y1}}{2} \quad (11)$$

where:

N	Number of coupon payments due
$D1M1Y1$	Previous coupon/issuance date
$D2M2Y2$	Settlement date
$D3M3Y3$	Next coupon/redemption date

15. Bill yield curve is constructed as follows:

15.1 Same maturity Bill yields with annual compounding and ACT/360 convention are calculated from the spot yield curve constructed in accordance with paragraph 14 of this document (formulae (1), (2), (3));

15.2 The interest rates with annual compounding and ACT/360 convention are linearly interpolated/extrapolated to calculate the yield-to-maturities for the tenors specified in clause 16.2 (formula 10).

E. Publishing and interpretation

16. Bill and Bond yield curves constructed respectively in accordance with paragraph 15 and paragraph 14 of this regulation are being published:

16.1 For Bonds, the yield curves are published for the following maturities:

Published maturities	Maturity (in years)
1 day	0.0027
1 month	0.0834
3 months	0.25
6 months	0.5
9 months	0.75
1 year	1
2 years	2
3 years	3
4 years	4
5 years	5
7 years	7
10 years	10
15 years	15
20 years	20
30 years	30

(clause 16.1 edited under the CBA Board resolution No. 1/197A, dated 22/03/2017)

16.2 For Bills, the yield curves are published for the following maturities:

Published maturity	Maturities (in days)
1 day	1
7 days	7
14 days	14
30 days	30
90 days	90
180 days	180
270 days	270
365 days	365

16.3 The yields are published once rounded to four decimal places after the comma in accordance with the Rounding rule.

Appendix 1

N	Description	Value
1	Minimum nominal value of transaction (AMD)	10,000,000 (ten million)
2	Number of business days	10 (ten)
3	Deviation (b. p.)	100 (one hundred)