Framework for the Calibration of the Countercyclical Capital Buffer Rate for Banks

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Acronyms

AUROC	Area Under the Receiver Operating Characteristic Curve
BCBS	Basel Committee on Banking Supervision
CAB	Current Account Balance
CBU	Central Bank of Uzbekistan
CCoB	Capital Conservation Buffer
CCyB	Countercyclical Capital Buffer
CET1	Common Equity Tier 1
D-SIB	Domestic Systemically Important Bank
ESRB	European Systemic Risk Board
FCI	Financial Conditions Index
FSAP	Financial Sector Assessment Program
FSI	Financial Stress Index
GDP	Gross Domestic Product
HP	Hodrick–Prescott
IMF	International Monetary Fund
LCR	Liquidity Coverage Ratio
MPP	Macroprudential Policy
NII	Net Interest Income
NPL	Non-Performing Loan
NSFR	Net Stable Funding Ratio
PCA	Principal Component Analysis
pnCCyB	Positive Neutral Countercyclical Capital Buffer
ROA	Return on Assets
ROE	Return on Equity
RWA	Risk-Weighted Assets

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Introduction

Ensuring the stability of the banking system is one of the main objectives[1] of the Central Bank of Uzbekistan (CBU). In this context, the CBU conducts macroprudential policy (MPP) to safeguard financial system stability in Uzbekistan.

In 2023, the CBU developed the MPP Framework[2], articulating the overarching conceptual basis for MPP implementation to enhance the stability of the financial system.

The Basel Committee on Banking Supervision (BCBS) recommends implementing the countercyclical capital buffer (CCyB), a MPP tool grounded in high-quality capital, to reinforce both the qualitative and quantitative dimensions of banks' capital[3].

The final report of the Financial Sector Assessment Program (FSAP), conducted in Uzbekistan in 2024–2025 by the International Monetary Fund (IMF) and the World Bank, emphasizes the need to strengthen MPP tools by introducing capital buffers, including a CCyB with a positive neutral rate (pnCCyB)[4].

Based on the recommendations of international financial organizations – including the BCBS, the IMF, the World Bank, and the European Systemic Risk Board[5] (ESRB) – as well as international best practices, the framework for setting the CCyB rate for banks has been developed.

Framework for the calibration of the CCyB rate for banks articulates the general conceptual basis for its determination and adjustment, consistent with the CBU's MPP Framework and Basel III standards.

Overview, financial cycle phases, effective indicators, and quantitative approaches for calibrating the pnCCyB and CCyB rates are also outlined in the framework.

Revisions and updates to the framework may occur in response to changes in the set of effective indicators used for financial stability analysis, improvements in quantitative approaches, legislative amendments, or recommendations from international financial organizations.

[1] O'zbekiston Respublikasining 2019-yil 11-noyabrdagi "O'zbekiston Respublikasining Markaziy banki to'g'risida"gi yangi tahrirdagi O'RQ-582–son Qonuni.

[2] The Central Bank of the Republic of Uzbekistan. (2023). The Central Bank of Uzbekistan Macroprudential Policy Framework.

[3] Basel Committee on Banking Supervision. (2010, December). Basel III: A global regulatory framework for more resilient banks and banking systems.

[4] International Monetary Fund. (2025, June). Republic of Uzbekistan: Financial Sector Assessment Program-Financial System Stability Assessment.

[5] European Systemic Risk Board. (2014). Recommendation of the European Systemic Risk Board of 18 June 2014 on guidance for setting countercyclical buffer rates.

I. Overview

The CCyB is applied to banks to support the continuity of credit to the real economy during periods of financial weaknesses and to strengthen the resilience of the banking system against cyclical systemic risks that build up during periods of excessive credit growth. The CBU raises the CCyB during the upswing of the financial cycle and releases it during downturns to support continued lending to the real economy.

The CCyB is composed of Common Equity Tier 1 (CET1) and ranges from 0% to 2.5% of risk-weighted assets (RWA). The CBU reviews the CCyB rate semi-annually, while the pnCCyB rate is reviewed every three years.

To allow banks sufficient time to adapt to the additional capital requirements and develop capital plans, the CBU's decision to raise the CCyB rate will take effect twelve months after its publication. Decisions to release the CCyB rate partially or fully will take effect immediately upon publication.

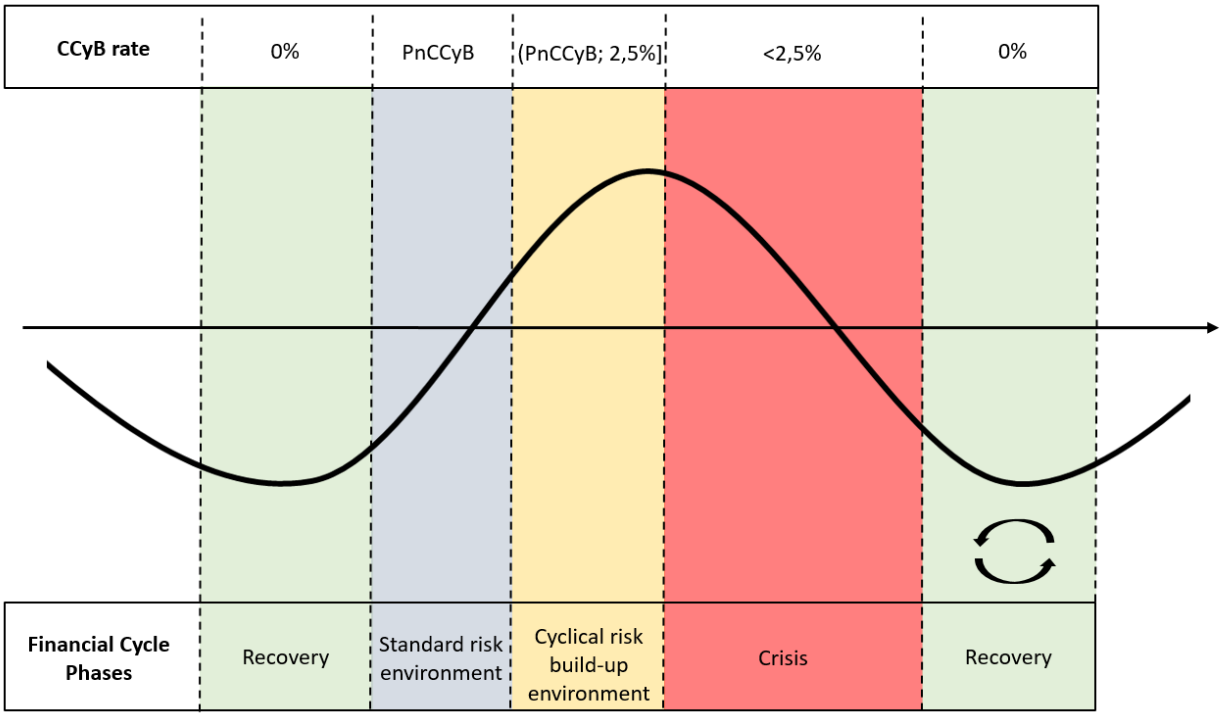
Given the dynamic evolution of systemic risks, the imperfect signaling from risk indicators, and the potential for different indicators to point to conflicting outcomes across multiple transmission channels, the CBU will uphold a guided discretion approach to the CCyB within its MPP.

II. Financial Cycle Phases

When determining the CCyB rate, the CBU first identifies the current phase of the financial cycle in Uzbekistan. Effective indicators are analyzed to assess current phase.

The phases of the financial cycle are categorized as recovery, standard risk, cyclical risk build-up, and crisis periods. Systemic risk levels differ across these phases, and the CCyB rate is determined according to the phase in which the economy is currently in.

Figure 1. CCyB Rate During Financial Cycle Phases



Source: CBU.

Recovery phase. This phase of the financial cycle corresponds to the post-crisis period. During the economic recovery phase, the uncertainties associated with the crisis subside. Recovery occurs in both the financial and non-financial sectors. The quality of bank assets begins to improve, and asset losses decrease. Bank profitability indicators improve, and capital adequacy levels increase.

Effective indicators are formed below their long-term averages. Under the influence of the economic downturn following the crisis, the country's GDP remains below its potential. The risk appetite of financial market participants declines, and real estate price growth remains at historically low levels. Demand for credit is low, and credit expansion slows.

In the economic recovery phase, the CCyB rate will be maintained at 0% relative to RWA in order to encourage banks to provide credit and restore economic activity.

Standard risk environment. After the recovery phase of the financial cycle, a standard risk environment emerges. As a result of timely and effective MPP tools aimed at reducing rising systemic risks, the financial cycle may return from the cyclical risk build-up phase to a standard risk environment.

In the standard risk environment phase of the financial cycle, systemic risks remain at a moderate level. The risk appetite of financial market participants begins to increase, and the recovery of economic activity is reflected in rising borrower incomes. In the real estate market, residential property prices are formed around their fundamental values.

Effective indicators are formed around their historical averages. Losses on bank assets do not increase, and the volume of credits expands. Banks' profitability and asset size increase.

The pnCCyB is set during the standard risk environment phase of the financial cycle.

Cyclical risk build-up phase. The cyclical risk build-up phase usually occurs after the standard risk environment in the financial cycle. However, due to the materialization of unexpected external risks, the economy may also transition directly from the recovery phase to the cyclical risk build-up phase.

In the risk build-up phase, the risk appetite of financial market participants increases. Under conditions of high economic growth, banks ease credit conditions and accelerate credit allocation. The volume of bank assets rises sharply.

During the risk build-up phase of the financial cycle, effective indicators exceed their historical averages. In the real estate market, housing prices remain elevated, and instances of overvaluation emerge relative to their fundamental values.

During the cyclical risk build-up phase of the financial cycle, the CCyB is set at up to 2.5% above the pnCCyB rate relative to RWA.

Crisis period. The crisis period of the financial cycle is characterized by large losses in the banking sector and high stress in the financial market.

During a crisis, credit growth slows down sharply. Asset prices also tend to fall, and financial conditions tighten.

To determine the crisis phase of the financial cycle, effective indicators such as the yield and G-spread of Uzbekistan's sovereign eurobonds, the financial stress index (FSI)[6], the financial conditions index (FCI)[7], and the growth of non-performing loans (NPLs) in the loan portfolio are used. The high formation of these indicators signals the occurrence of a crisis phase of the financial cycle.

In the presence of systemic risks during the crisis phase of the financial cycle, the CCyB may be partially or fully released to support economic activity and strengthen banks' capacity to provide credit.

When partially or fully releasing the CCyB rate, the severity of the crisis and the available resource capacity of banks are assessed to prevent disruptions in lending. In particular, a decision to partially release the CCyB rate is based on banks' capital adequacy ratios being above the established requirements and the availability of excess capital. In cases where capital adequacy ratios are close to the minimum requirements, the CCyB rate can be fully released.

The phases of the financial cycle repeat, moving from a period of crisis to a period of recovery.

[6] Detailed information on the Financial Stress Index is presented in the Financial Stability Report for 2022.

[7] Detailed information on the Financial Conditions Index is presented in the Financial Stability Report for 2023.

III. Effective Indicators

Effective indicators for determining the CCyB rate were selected from a wide range of indicators recommended by international financial institutions and based on international experience, taking into account the availability of sufficiently long time series and the results of the area under the receiver operating characteristic curve[8] (AUROC)[9].

Based on the AUROC results, effective indicators representing the macroeconomic, financial, and non-financial sectors, as well as the real estate market, were selected (Appendix 1).

Over time, the scope of indicators may be adjusted as systemic risk drivers and the characteristics of financial system development evolve.

[8] Detailed information on AUROC is provided in the CBU's research.

[9] AUROC results fall between 0 and 1, meaning that indicators with higher AUROC values are more likely to accurately reflect periods of crisis.

Table 1. List of Effective Indicators

Group	Indicator
Macroeconomic indicators	Credit to the private sector-to-GDP gap
	Difference between interest rates on loans in national currency and treasury bonds
	FCI
	Total credit-to-GDP gap
	Nominal GDP gap
	Inflation
	FSI
	Uzbekistan's sovereign Eurobond G-spread
	Credit-to-GDP growth rate
	Current account balance (CAB) to GDP ratio
	Financial cycle index
Financial sector	Loan to deposit ratio
	Return on equity (ROE)
	Growth rate of NPLs
	Banking system assets-to-GDP ratio
	Net stable funding rate ratio (NSFR)
	Loan growth rate
	Share of FX loans
	Return on assets (ROA)
	Leverage ratio
	CET1 capital ratio
Non-financial sector	Household loan growth
	Corporate credit-to-GDP gap
	Household credit-to-GDP gap
	Share of corporate loans
	Corporate loan growth rate
Real estate market	Housing price-to-disposable income ratio
	Mortgage loan growth rate
	Housing price growth rate
	Difference between market and fundamental housing prices

Source: CBU.

Note: The indicators in the groups are presented in descending order based on the AUROC result.

IV. Quantitative Approaches for Calibrating the Countercyclical Capital Buffer Rate

Quantitative approaches are used to determine the CCyB and pnCCyB rates. In addition to the presented approaches, the CBU may apply supplementary approaches when determining buffer rates.

4.1. Countercyclical Capital Buffer Rate

Quantitative approaches used to determine the CCyB rate include the benchmark buffer rate, solvency macro stress tests, the historical losses approach, multivariate logit models, and a composite index.

A. Benchmark Buffer Rate Approach

The benchmark CCyB rate is detirmined based on the credit to the private sector-to-GDP gap.

The credit to the private sector-to-nominal GDP gap is calculated by finding the difference between this ratio and its long-term trend:

$$GAP_t = Ratio_t - Trend_t$$

Where,
GAP_t – credit to the private sector-to-GDP gap in period *t*;
$Ratio_t$ – credit to the private sector-to-GDP ratio in period *t*;
$Trend_t$ – long-term trend of the credit to the private sector-to-GDP ratio in period *t.*

The long-term trend of the credit to the private sector-to-GDP ratio is determined using the Hodrick-Prescott (HP) filter. In line with Basel recommendation[10], a smoothing parameter of 400,000 is used to determine the long-term trend based on quarterly data.

When determining the acceptable benchmark rate of the buffer, the BCBS's[11] lower and upper thresholds for the credit-to-GDP gap are used.

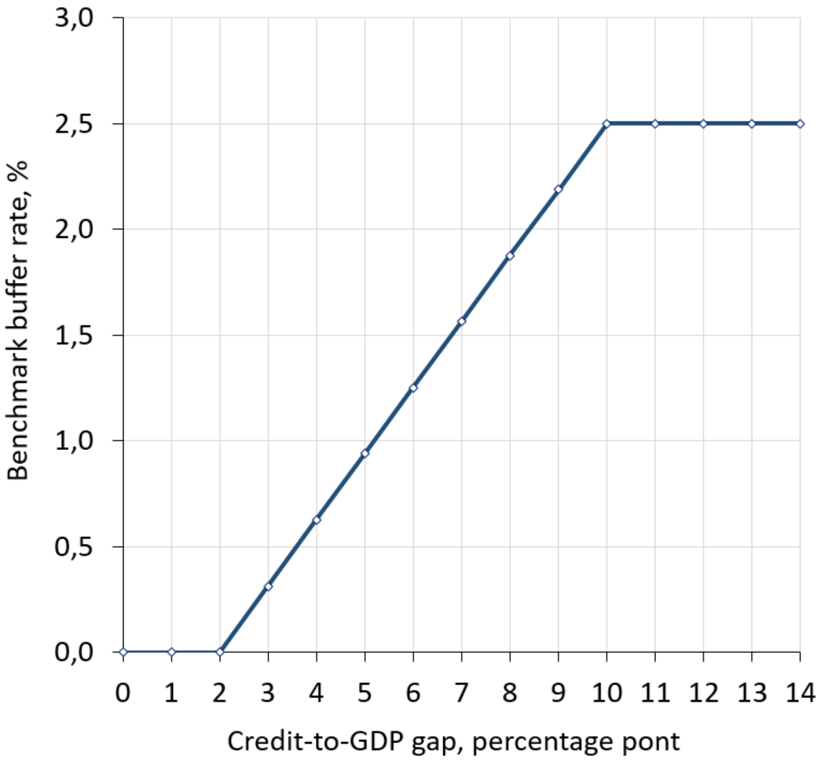
$$CCyB = \begin{cases} 0\% & \text{if, } GAP_t < 2 \text{ p.p.} \\ 0{,}3125 * GAP_t - 0{,}625 & \text{if, } 2 \text{ p.p.} \leq GAP_t \leq 10 \text{ p.p.} \\ 2{,}5\% & \text{if, } GAP_t > 10 \text{ p.p.} \end{cases}$$

Where,
$CCyB$ – countercyclical capital buffer rate;
GAP_t – credit to the private sector-to-GDP gap.

[10] Basel Committee on Banking Supervision. (2010, December). Guidance for national authorities operating the countercyclical capital buffer.

[11] Basel Committee on Banking Supervision. (2010, December). Guidance for national authorities operating the countercyclical capital buffer.

Figure 2. Benchmark CCyB Rate



Source: BCBS.

The benchmark CCyB rate is formed linearly from 0% to 2.5% depending on credit to the private sector-to-GDP gap. When the gap is 2 percentage points (p.p.) or less, the benchmark buffer rate is 0% of RWA. When the gap reaches 10 p.p. or more, the benchmark buffer rate corresponds to 2.5%.

B. Solvency Macro Stress Test Approach

According to the solvency macro stress test approach, the difference between the CET1 capital ratio assessed under the adverse scenario and the initial period of the stress test represents the overall rate of MPP capital buffers required to maintain the stable operation of banks.

$$CCyB = (CET1_{t+1}^{S} - CET1_t) - \left(CCoB + D\text{-}SIB\_b * \frac{RWA_{D-SIB}}{RWA_T}\right)$$

Where,
$CET1_{t+1}^{S}$ – CET1 capital ratio estimated for the period beyond one year under the adverse scenario;
$CET1_t$ – CET1 capital ratio at the beginning of the macro stress test;
$CCoB$ – capital conservation buffer;
$D\text{-}SIB\_b$ – capital buffer for domestic systemically important banks;
RWA_{D-SIB} – RWA volume of D-SIBs;
RWA_T – RWA volume of banking system.
When determining the CCyB rate, the capital conservation buffer (CCoB) and the capital buffer for domestic systemically important banks (D-SIBs) are deducted from the total MPP capital

buffer rate. Since the D-SIB buffer applies only to certain banks, its impact on the banking system is calculated by multiplying the D-SIB buffer rate by the share of D-SIBs' RWA in the total RWA of the banking system.

C. Historical Losses Approach

The CCyB rate is determined based on historical observations of the capital required to cover losses incurred in the banking system. The decline in the banking system's capital adequacy after accounting for additional capital injections in previous periods represents the amount of losses currently absorbed by the banking system.

This approach considers the differences between the highest and lowest CET1 capital ratios during periods of historically sharp changes. The arithmetic mean of these differences represents the amount of capital required to ensure the stability of the banking system. The additional capital that banks need on average to address potential risks represents the overall rate of MPP capital buffers necessary to ensure the stable operation of the banking system.

$$CCyB = \left(\frac{\sum_{i=1}^{n}\left(CET1_{max,i} - CET1_{min,i}\right)}{n}\right) - \left(CCoB + D\text{–}SIB\_b * \frac{RWA_{D-SIB}}{RWA_T}\right)$$

Where,
$CET1_{max,i}$ – the highest CET1 capital ratio in historical i order periods of rapid change;
$CET1_{min,i}$ – the lowest CET1 capital ratio in historical i order periods of rapid change;
n – number of historical sharp changes in the CET1 capital ratio.

When determining the CCyB rate using the historical losses approach, the CCoB and the D-SIB buffer requirements are deducted from the total MPP capital buffer rate. The impact of the D-SIB buffer on the banking system is calculated by multiplying the D-SIB buffer rate by the share of D-SIBs' RWA in the total RWA of the banking system.

D. Multivariate Logit Model Approach

When implementing the multivariate logit model approach, the effective indicators are divided into subgroups with different combinations.

In a multivariate logit model, the number of subgroups of combined indicators is determined as follows:

$$A = \sum_{k=1}^{n} S_n^k = \sum_{k=1}^{n} \frac{n!}{k!\,(n-k)!} = 2^n - 1$$

Where,
A – number of combinations;
n – total number of indicators;
k – number of indicators in the combination.

By dividing the indicators into subgroups, various combination models are developed, and the probability of a crisis is estimated using a multivariate logit model.

The probability of a crisis through a multivariate logit model is estimated using the following formula:

$$P_{A,t} = E(Y_t = 1|X_{i,t})$$

$$P_{A,t} = \frac{1}{1 + e^{-(\alpha + \sum_{i=1}^{n} \beta_i X_{i,t})}}$$

Where,
$P_{A,t}$ – the probability of a crisis, estimated for period t by indicators in the combination group of order A;
Y_t – variable introduced to define crisis periods;
$X_{i,t}$ – independent variable of order i in period t;
A – number of combinations;
n – total number of indicators;
α, β – unknown parameters.

The multivariate logit model estimates the probability of a crisis by measuring the change in the values of the indicators. In this case, the unknown parameters are determined at the highest values of the log likelihood function[12], which is formed by the probability of a crisis.

Buffer rates are determined based on the end-period value of the probability of a crisis under various combinations.

[12] Gujarati, D.N. (2009). Basic Econometrics Fifth Edition. McGraw-Hill.

The log likelihood function is defined by the following formula:

$$\ln f(Y_1, Y_2, \dots, Y_t) = \ln\left(\prod_1^t f_t(Y_t)\right) = \ln\left(\prod_1^t {P_t}^{Y_t} * (1 - P_t)^{1-Y_t}\right)$$
$$= \sum_1^t [Y_t * lnP_t + (1 - Y_t) * \ln(1 - P_t)] = \sum_1^t \left[Y_t * \ln\left(\frac{P_t}{1 - P_t}\right)\right] + \sum_1^t \ln(1 - P_t)$$

Where,
Y_t – variable introduced to define crisis periods;
P_t – the probability of a crisis for period t.

Table 2. The Probability of a Crisis and Buffer Rate

The probability of a crisis	Buffer rate, %
0	0
(0; 0.1]	0.25
(0.1; 0.2]	0.50
(0.2; 0.3]	0.75
(0.3; 0.4]	1.00
(0.4; 0.5]	1.25
(0.5; 0.6]	1.50
(0.6; 0.7]	1.75
(0.7; 0.8]	2.00
(0.8; 0.9]	2.25
(0.9; 1]	2.50

Source: CBU.

The CCyB rate is represented by the weighted arithmetic average of the buffer rates derived from the results of the models across different indicator combinations, weighted by the number of combinations:

$$CCyB = \frac{0{,}25 * \sum_{j=1}^{n}\left(j * A_{0{,}25*j}\right)}{A}$$

Where,
$CCyB$ – countercyclical capital buffer rate;
j – buffer rate order with a multiple of 0.25 p.p.;
n – the number of total buffer rates ranked not more than 2.5%;
$A_{0{,}25*j}$ – number of combinations corresponding to a buffer rate of 0.25*j;
A – total number of combinations.

When the probability of a crisis is high, the required CCyB rate also increases. When the crisis probability equals one, the CCyB rate indicates the need to be set at the maximum of 2.5%.

E. Composite Index Approach

The effective indicators are standardized and aggregated into a single index in composite index approach. The CCyB rate is then determined based on this index.

The indicators are standardized using the Z-score method:

$$y_z = \frac{y_t - y_\mu}{\sigma_{y_t}}$$

Where,
y_z – standardized value of the indicator;
y_t – the value of the indicator in quarter t;

y_μ – arithmetic mean of the indicator;
σ_{y_t} – one standard deviation of the indicator[13].

To combine standardized indicators into a single index, principal component analysis (PCA)[14] is used, which reduces the number of dimensions through linear transformation, while preserving the existing variance of the indicators to the maximum extent possible.

The CCyB rate is determined based on the index results for combinations. The optimal lower and upper thresholds of the index are determined using the combination element of combinatorics, ordered logistic regression, and AUROC.

All combinations are determined by the combination element of combinatorics according to the 5 percentile steps of the lower and upper thresholds of the index, i.e. (0; 5); (0; 10); (0; 15); ... (90; 95); (95; 100):

$$C(p,q) = \frac{p!}{q!\,(p-q)!} = \frac{21!}{2! * (21-2)!} = \frac{20 * 21}{2} = 210$$

Where,

C – total number of combinations;
p – total number of percentiles in 5 percentile steps;
q – the number of percentiles involved in each combination.

The CCyB rates for the lower and upper thresholds of a total of 210 combinations, as well as the ultimately determined optimal thresholds, are calculated as follows:

$$CCyB_t = \begin{cases} 0 & \text{if } V_t < V^L \\ 2.5\% * \left(\frac{V_t - V^L}{V^H - V^L}\right) & \text{if } V^L \leq V_t \leq V^H \\ 2.5\% & \text{if } V_t > V^H \end{cases}$$

Where,

$CCyB_t$ – countercyclical capital buffer in period t;
V_t – index value in period t;
V^L – lower threshold of the index;
V^H – upper threshold of the index.

[13] One standard deviation of an indicator is determined by the following formula:

$$\sigma_{y_t} = \sqrt{\sum \frac{(y_t - y_\mu)^2}{n-1}}$$

σ_{y_t} – one standard deviation of the indicator;
y_t – the value of the indicator in quarter t;
y_μ – arithmetic mean of the indicator;
n – number of observations.

[14] Detailed information on PCA is presented in Central Bank research.

The level of credit risk, determined by the distribution of the NPL share in the total loan portfolio in quartiles (25 percentile, 50 percentile, 75 percentile), is divided into 4 groups:

$$NPL\_Dummy_t = \begin{cases} 1 & \text{if} \quad NPL_t \leq NPL^{25} \\ 2 & \text{if} \quad NPL^{25} < NPL_t \leq NPL^{50} \\ 3 & \text{if} \quad NPL^{50} < NPL_t \leq NPL^{75} \\ 4 & \text{if} \quad NPL^{75} < NPL_t \end{cases}$$

Where,
NPL_Dummy_t – credit risk level in period t;
NPL_t – the share of NPLs in the total loan portfolio in period t;
NPL^{25}, NPL^{50}, NPL^{75} – values of the distribution of the share of NPLs in the total loan portfolio at the 25th, 50th, and 75th percentiles, respectively.

Credit risk is lowest in periods when the NPL ratio is 25 percentile or lower, and highest in periods when it is above the 75 percentile.

The probability of credit risk levels is estimated using a logistic regression model, which is ranked by the one-year-ago value of CCyB rates calculated at different percentiles of the lower and upper thresholds of the composite index:

$$NPL\_Dummy_t = \alpha + \beta CCyB_{t-4}$$
$$Pr_t^1 = \Pr(NPL\_Dummy_t = 1 | \, CCyB_{t-4})$$
$$Pr_t^2 = \Pr(NPL\_Dummy_t = 2 | \, CCyB_{t-4})$$
$$Pr_t^3 = \Pr(NPL\_Dummy_t = 3 | \, CCyB_{t-4})$$
$$Pr_t^4 = \Pr(NPL\_Dummy_t = 4 | \, CCyB_{t-4})$$

Where,
$CCyB_{t-4}$ – countercyclical capital buffer at period $t-4$;
α, β – unknown parameters;
Pr_t^1, Pr_t^2, Pr_t^3, Pr_t^4 – probabilities of occurrence of credit risk levels estimated through an ordered logistic regression model.

Through the ordered logistic regression model, the probability of an event occurring is determined by the logistic distribution function[15]:

$$\mathrm{P}(Y_i = 1) = 1 - \frac{e^{(X_i\beta - k_1)}}{1 + e^{(X_i\beta - k_1)}}$$

$$\mathrm{P}(Y_i = j) = \frac{e^{(X_i\beta - k_1)}}{1+e^{(X_i\beta - k_1)}} - \frac{e^{(X_i\beta - k_j)}}{1+e^{(X_i\beta - k_j)}}, \, j = 2, \dots, M-1$$

[15] Williams, R. (2024). Ordered Logit Models – Basic & Intermediate Topics. University of Notre Dame.

$$P(Y_i = M) = \frac{e^{(X_i\beta - k_{M-1})}}{1 + e^{(X_i\beta - k_{M-1})}}$$

According to the ordered logistic regression model, the probability of occurrence of a credit risk level is expressed by the following logistic distribution functions:

$$Pr_t^1 = \Pr(NPL\_Dummy_t = 1|\ CCyB_{t-4}) = \frac{1}{1 + e^{(\beta * CCyB_{t-4} - k_1)}}$$

$$Pr_t^2 = \Pr(NPL\_Dummy_t = 2|\ CCyB_{t-4}) = \frac{1}{1 + e^{(\beta CCyB_{t-4} - k_2)}} - \frac{1}{1 + e^{(\beta * CCyB_{t-4} - k_1)}}$$

$$Pr_t^3 = \Pr(NPL\_Dummy_t = 3|\ CCyB_{t-4}) = \frac{1}{1 + e^{(\beta CCyB_{t-4} - k_3)}} - \frac{1}{1 + e^{(\beta * CCyB_{t-4} - k_2)}}$$

$$Pr_t^4 = \Pr(NPL\_Dummy_t = 4|\ CCyB_{t-4}) = 1 - \frac{1}{1 + e^{(\beta * CCyB_{t-4} - k_3)}}$$

Where, $k_1, k_2, k_3\ \beta$ – unknown parameters.

To calculate the probability of occurrence of a credit risk level, the values of unknown parameters are determined. The values of unknown parameters in logistic distribution functions are determined by finding the maximum value of the log likelihood function.

The ability of the estimated credit risk probability to represent the appropriate credit risk level is assessed using the AUROC model:

$$AUROC_{m,n} = \Big(AUROC_{m,n}(NPL\_Dummy_t^1; Pr_t^1) + AUROC_{m,n}(NPL\_Dummy_t^2; Pr_t^2) + AUROC_{m,n}(NPL\_Dummy_t^3; Pr_t^3) + AUROC_{m,n}(NPL\_Dummy_t^4; Pr_t^4)\Big)/4$$

Where,

$AUROC_{m,n}$ – the average AUROC result for the m and n percentiles of the lower and upper thresholds;
$AUROC_{m,n}(NPL\_Dummy_t^1; Pr_t^1)$ – the AUROC result on the ability of the probability of occurrence of a credit risk level set as one to represent this credit risk level;
$AUROC_{m,n}(NPL\_Dummy_t^2; Pr_t^2)$ – the AUROC result on the ability of the probability of occurrence of a credit risk level defined as two to represent this credit risk level;
$AUROC_{m,n}(NPL\_Dummy_t^3; Pr_t^3)$ – the AUROC result on the ability of the probability of occurrence of a credit risk level defined as three to represent this credit risk level;
$AUROC_{m,n}(NPL\_Dummy_t^4; Pr_t^4)$ – the AUROC result on the ability of a probability of occurrence of a credit risk level defined as four to represent this credit risk level.
m – lower threshold percentile level;
n – upper threshold percentile level.

The highest value of the AUROC results calculated at different percentiles of the lower and upper thresholds of the index indicates the optimal thresholds (Appendix 2).

According to the AUROC results, the same optimal values were identified for the upper threshold at the 90th percentile and the lower threshold at the 35th, 40th, and 45th percentiles. In finding a single optimal value for the lower threshold, the weighted average AUROC is estimated by giving a higher weight to the AUROC value for the 35th, 40th, and 45th percentiles for their ability to represent higher credit risk levels:

$$AUROC_{m,n} = \Big(AUROC_{m,n}\left(NPL_{Dummy}{}^{1}_{t}; Pr_t^1\right) * 1 + AUROC_{m,n}(NPL\_Dummy_t^2; Pr_t^2) * 2 + AUROC_{m,n}(NPL\_Dummy_t^3; Pr_t^3) * 3 + AUROC_{m,n}(NPL\_Dummy_t^4; Pr_t^4) * 4\Big) /10$$

The percentile value corresponding to the largest value among the weighted average AUROC results is considered as the optimal lower threshold:

$$AUROC_{m,\,n} = \max\big(AUROC_{35,\,90};\ AUROC_{40,\,90}; AUROC_{45,\,90}\big)$$

Based on the highest value of the weighted average AUROC, the 35th and 90th percentiles were adopted for the optimal lower and upper thresholds.

If the index value in the most recent observation period falls below the 35th percentile of the index distribution, the CCyB rate is set at 0%. If the index value in the last observation period exceeds the 90th percentile, the CCyB rate is set at 2.5%. For index values in the last observation period between the 35th and 90th percentiles of the index distribution, the CCyB rate is set between 0% and 2.5%.

4.2. Positive Neutral Countercyclical Capital Buffer Rate

The quantitative approaches used to determine the pnCCyB rate include the from losses to buffer approach, the solvency macro stress test, the multivariate logit model, and the composite index.

A. From Losses to Buffer Approach

The pnCCyB rate is determined using from losses to buffer approach. Under this approach, the effects of banking activity and macrofinancial indicators, together with bank and time fixed effects, on banks' ROA are estimated using a quantile regression model based on panel data[16].

The quantile regression model for ROA is specified as follows:

$$Q_{\pi_{i,t+h}}\big(\tau \big| X_{i,t}, Y_t\big) = X_{i,t}'\beta^{\tau} + Y_t'\delta^{\tau} + \alpha_i^{\tau} + \lambda_t^{\tau} + \epsilon_{i,t+h}$$

Where,

Q – ROA;
X – banking activity indicators;

[16] Detailed information on the quantile regression model is presented in the Financial Stability Report for 2024.

Y – macrofinancial indicators;
t – quarters;
i – banks;
τ – quantile value;
h – number of lag periods in independent variables;
β, δ – unknown parameters;
α – bank fixed effects;
λ – time fixed effects;
ϵ – error term.

The quantile regression model takes into account banking performance and macrofinancial indicators that affect ROA.

Table 3. Banking Activity and Macro-Financial Indicators

Group	Indicator
Banking activity indicators	Asset volume
	Share of NPLs in total loans
	Ratio of net interest income (NII) to interest-bearing assets
	Share of net loans in total assets
	Cost-to-income ratio
	RWA density
	CET1 capital ratio
	Leverage ratio
Macrofinancial indicators	Real GDP growth rate
	FSI
	Uzbekistan sovereign Eurobond G-spread

Source: CBU.

The lower percentiles of the ROA distribution are associated with higher losses. The pnCCyB rate is determined by the results of a quantile regression model based on panel data at the 25th percentile of ROA.

Given that the increase in the buffer rate is determined 4 quarters in advance, the independent variables in the quantile regression model affect ROA with a lag of 4 quarters.

The pnCCyB rate is determined by the following formula:

$$pnCCyB = \frac{1}{T^*}\sum_{t=1}^{T^*} max\left\{0, \frac{-\lambda_t^\tau}{\overline{rw}_t}\right\}$$

Where,

$\overline{rw}$ – average RWA density[17];
T^* – number of periods with negative time fixed effects.

Negative values of the coefficient λ are taken into account as the negative impact of time fixed effects on ROA. The pnCCyB rate is determined by dividing the negative impact on ROA calculated by the model with the simple arithmetic mean value of the RWA density.

B. Solvency Macro Stress Test Approach

In the solvency macro stress test approach, the pnCCyB rate is determined based on a moderate scenario. The difference between the CET1 capital ratio estimated under the moderate scenario and the initial stress test period represents the overall level that should be covered by MPP capital buffers.

$$pnCCyB = (CET1_{t+1}^{M} - CET1_t) - \left(CCoB + D\text{–}SIB\_b * \frac{RWA_{D-SIB}}{RWA_T}\right)$$

Where,
$CET1_{t+1}^{M}$ – CET1 capital ratio estimated for the period beyond one year under the moderate scenario.

When determining the pnCCyB rate, the buffer requirements for CCoB and D-SIB are subtracted from the total level of the MPP capital buffer (see Part B of Chapter 4.1.).

C. Multivariate logit model approach

The medians of the results are used to determine the pnCCyB rate through a multivariate logit model. A higher median value of the probability of a crisis situation occurring corresponds to a higher value of the pnCCyB rate.

The pnCCyB rate is represented by the weighted arithmetic mean of the various pnCCyB rates corresponding to the median model output. The weights are based on the number of different combinations that represent buffer rate (see Part D of Chapter 4.1.).

D. Composite Index Approach

Under the composite index approach, indicators are standardized and combined into a single composite index.

Based on the value of the composite index, the pnCCyB rate is determined as follows:

$$pnCCyB = 2{,}5\% * \left(\frac{V^{60} - V^{35}}{V^{90} - V^{35}}\right)$$

Where,

[17] The density of risk-weighted assets is found by the ratio of risk-weighted assets to total assets.

V^{35} – value at the 35th percentile of the index distribution;
V^{60} – value at the 60th percentile of the index distribution;
V^{90} – value at the 90th percentile of the index distribution.

The composite index approach uses the 35th and 90th percentiles as the lower and upper thresholds of the index to determine the CCyB rate. The pnCCyB rate is determined by taking the historical 60th percentile of the index result.

4.3. Aggregation of Quantitative Approach Results to Single Rate

The rounded results of the quantitative approaches applied to both CCyB and pnCCyB are consolidated into a single rate, which is then used to draw conclusions on the CCyB rate. Specifically, the results of the quantitative approaches for CCyB and pnCCyB, along with the consolidated single rate, are rounded up to the nearest multiple of 0.25 p.p.:

$$\tilde{r} = \min\left(\max\left(\frac{\lceil \hat{r} * 4 \rceil}{4}; 0\right); 2{,}5\right)$$
$$r \in \{R_i; \bar{R}\}$$

Where,
$\lceil \hat{r} \rceil$ – the nearest integer not less than $\hat{r}$;
$\tilde{r}$ – the rounded value of either the single rate of the quantitative approach or their results;
$\hat{r}$ – the unrounded value of either the single rate of the quantitative approach or their results;
R_i – quantitative approach results;
$\bar{R}$ – a single rate of quantitative approach results;
min – the smallest value between the indicators;
max – the largest value between the indicators.

Rounding is performed to the nearest buffer rate that is a multiple of 0.25 percentage points and is not less than the unrounded value of either the results of the quantitative approaches or their single rate. In this case, the rounded values are formed between 0% and 2.5%.

The single rate is calculated as the arithmetic mean of the rounded results from the quantitative approaches for both CCyB and pnCCyB:

$$\bar{R} = \frac{\sum_{i=1}^{n} R_i}{n}$$
$$R \in \{CCyB; pnCCyB\}$$

Where,

$\bar{R}$ – a single rate of quantitative approach results for $CCyB$ or $pnCCyB$;
R_i – the $CCyB$ or $pnCCyB$ rate determined by the i order quantitative approach;
n – number of quantitative approaches.

The results of the CCyB quantitative approaches are consolidated into a single rate by calculating the simple arithmetic mean of the rounded outcomes from the benchmark CCyB rate, the solvency macro stress test, historical loss analysis, the multivariate logit model, the composite index, and other quantitative approaches used to determine the CCyB rate.

The single pnCCyB rate is determined by calculating the simple arithmetic mean of the rounded results obtained from losses to buffer approach, the solvency macro stress test, the multivariate logit model, the composite index, and any additional quantitative approaches applied.

When determining the CCyB rate, the largest buffer rate between the single rates of the quantitative approaches for CCyB and pnCCyB is adopted:

$$CCyB = max\ (CCyB;\ pnCCyB)$$

Where,
$CCyB$ – countercyclical capital buffer rate;
$pnCCyB$ – positive neutral countercyclical capital buffer rate;
max – the largest value between the indicators.

If the single rate derived from the quantitative approaches used to determine the CCyB rate is lower than the pnCCyB rate, the CCyB rate is set at a level no lower than the pnCCyB rate.

Appendix

Appendix 1

Table 4. Description of Effective Indicators

Indicator	Identification	Measuring unit	Risk direction
	I. Macroeconomic indicators		
Credit to the private sector-to-GDP gap	Credit to the private sector-to-GDP gap is calculated as the actual private sector credit-to-GDP ratio minus its long-term trend. The long-term trend is determined using a one-sided HP filter with a smoothing parameter of 400,000 for quarterly data.	p.p.	Positive
Difference between interest rates on loans in national currency and treasury bonds	The average interest rate on treasury bonds is subtracted from the average lending interest rate in national currency.	p.p.	Positive
FCI	The final FCI is computed by applying PCA to combine sub-indices for the banking sector, FX market, external sector, and macroeconomic indicators.	Index	Positive
Total credit-to-GDP gap	The credit-to-GDP gap is calculated as the actual credit-to-GDP ratio minus its long-term trend. The long-term trend is determined using a one-sided HP filter with a smoothing parameter of 400,000 for quarterly data.	p.p.	Positive
Nominal GDP gap	The nominal GDP gap is calculated as the actual nominal GDP minus its long-term trend. The long-term trend of nominal GDP is determined using a one-sided HP filter with a smoothing parameter of 400,000 for quarterly data.	p.p.	Negative
Inflation	The annual change in the consumer price index is taken.	%	Positive
FSI	The index is calculated as the weighted sum of the sub-indices for the money market, domestic currency market, and banking sector.	Index	Positive
Uzbekistan's sovereign Eurobond G-spread	The yield on benchmark bonds is subtracted from the yield of Uzbekistan's sovereign bonds denominated in FX. The overall G-spread indicator is determined by calculating the weighted arithmetic average of the G-spread for each Eurobond and the volume of the bonds.	p.p.	Positive
Credit-to-GDP growth rate	The annual change in the ratio of total credit to nominal GDP is determined.	p.p.	Positive
CAB to GDP ratio	It is calculated by dividing the CAB to nominal GDP.	%	Negative
Financial cycle index	Indicators are standardized using the Z-score method and combined into a financial cycle index using PCA.	Index	Negative

	II. Financial sector		
Loan to deposit ratio	It is calculated as the ratio of outstanding bank loans to outstanding deposits.	%	Positive
ROE	It is calculated by the ratio of net profit to total capital in the banking system.	%	Negative
Growth rate of NPLs	It is calculated by calculating the annual growth rate of the outstanding NPLs compared to the value one year ago.	%	Positive
Banking system assets-to-GDP ratio	It is calculated by dividing the size of the banking system's assets by the amount of nominal GDP.	%	Negative
NSFR	NSFR is defined as the ratio of the available amount of stable funding to the required amount of stable funding.	%	Negative
Loan growth rate	It is calculated by the annual nominal growth rate of total outstanding loans compared to the value one year ago.	%	Positive
Share of FX loans	It is calculated as the ratio of outstanding FX loans to total outstanding loans.	%	Positive
ROA	It is calculated as the ratio of net profit before tax to total assets in the banking system.	%	Negative
Leverage ratio	It is calculated by the ratio of Tier I capital to total assets.	%	Negative
CET1 capital ratio	It is calculated by the ratio of CET1 to RWA.	%	Negative
	III. Non-financial sector		
Household loan growth	It is the annual growth rate of the outstanding loans issued to individuals.	%	Positive
Corporate credit-to-GDP gap	The gap is calculated as the actual corporate credit-to-GDP ratio minus its long-term trend. The long-term trend is determined using a one-sided HP filter with a smoothing parameter of 400,000 for quarterly data.	p.p.	Positive
Household credit-to-GDP gap	The gap is calculated as the actual household credit-to-GDP ratio minus its long-term trend. The long-term trend is determined using a one-sided HP filter with a smoothing parameter of 400,000 for quarterly data.	p.p.	Positive
Share of corporate loans	It is calculated as the ratio of outstanding loans to legal entities to total loan portfolio.	p.p.	Positive
Corporate loan growth rate	It is the annual growth rate of the outstanding loans issued to legal entities.	%	Positive
	IV. Real estate market		
Housing price-to-disposable income ratio	It is calculated as the ratio of the market price of houses to the household disposable income. Household disposable income is obtained by subtracting taxes and mandatory payments from the average nominal wage.	%	Positive

Mortgage loan growth rate	It is the annual growth rate of the outstanding mortgage loans issued to individuals.	%	Positive
Housing price growth rate	The annual growth rate of housing prices is taken into account.	%	Positive
Difference between market and fundamental housing prices	The difference is calculated as the deviation of the market price of houses to the average fundamental price determined by models.	%	Positive

Note: The indicators in the groups are presented in descending order based on the AUROC result.

A positive direction indicates that an increase in the indicator is associated with an increase in vulnerability. Conversely, a negative direction indicates that an increase in the indicator is associated with a decrease in vulnerability.

Table 5. AUROC Results Calculated Based on Different Percentiles for the Lower and Upper Thresholds of the Index

Upper threshold

Lower threshold	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
0	0.50	0.50	0.50	0.53	0.50	0.55	0.53	0.45	0.43	0.41	0.43	0.42	0.40	0.38	0.39	0.64	0.63	0.64	0.64	0.64
5		0.50	0.50	0.53	0.50	0.55	0.53	0.45	0.43	0.41	0.43	0.42	0.40	0.38	0.39	0.64	0.63	0.64	0.64	0.64
10			0.50	0.53	0.50	0.55	0.53	0.45	0.43	0.41	0.43	0.42	0.40	0.38	0.39	0.64	0.63	0.64	0.64	0.64
15				0.53	0.50	0.55	0.53	0.45	0.43	0.41	0.43	0.42	0.40	0.38	0.39	0.64	0.63	0.64	0.64	0.64
20					0.50	0.45	0.47	0.45	0.43	0.41	0.43	0.42	0.40	0.38	0.39	0.64	0.63	0.64	0.64	0.64
25						0.45	0.47	0.45	0.43	0.41	0.43	0.42	0.40	0.38	0.39	0.64	0.63	0.64	0.64	0.64
30							0.47	0.45	0.43	0.40	0.43	0.41	0.40	0.38	0.39	0.64	0.64	0.64	0.64	0.65
35								0.46	0.43	0.41	0.44	0.42	0.41	0.39	0.39	0.63	0.63	0.66	0.64	0.64
40									0.43	0.40	0.43	0.42	0.40	0.38	0.39	0.64	0.63	0.66	0.64	0.64
45										0.40	0.43	0.41	0.39	0.38	0.62	0.64	0.64	0.66	0.64	0.64
50											0.44	0.42	0.41	0.39	0.61	0.63	0.63	0.64	0.64	0.64
55												0.44	0.42	0.59	0.59	0.62	0.61	0.62	0.61	0.61
60													0.59	0.61	0.60	0.63	0.62	0.63	0.62	0.63
65														0.62	0.61	0.64	0.63	0.62	0.62	0.63
70															0.62	0.65	0.64	0.65	0.63	0.63
75																0.64	0.63	0.64	0.62	0.62
80																	0.65	0.65	0.63	0.64
85																		0.60	0.59	0.59
90																			0.60	0.61
95																				0.60

Source: CBU staff calculations.

Note: The blue cells represent the highest AUROC result and the percentile values of the optimal lower and upper thresholds of the corresponding index.