



A FOUR-DIMENSIONAL MODEL FOR ASSESSING THE FINANCIAL STABILITY OF COMMERCIAL BANKS UNDER CIRCULAR ECONOMY CONDITIONS: METHODOLOGY AND EMPIRICAL RESULTS

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ABSTRACT	KEYWORDS
This article presents a new theoretical and methodological approach to assessing the financial stability of commercial banks under circular economy conditions. For the first time, financial stability is defined through a four-dimensional integrated approach combining operational (CIR, ROA, ROE), capital (CAR, NPL, liquidity), adaptive (stress-testing, diversification) and ecological-circular (GLR, ESG rating) components, the application of which increases assessment accuracy by 25-30%. The factors affecting financial stability are, for the first time, classified into six groups: macroeconomic, legal-regulatory, institutional, socio-demographic, internal-bank and ecological-circular. An empirical study of JSC “Milliy Bank”, JSCB “SQB” and JSCB “Asakabank” over 2021-2025 confirmed that the Z-score ranges from 27.35 to 66.58, placing all three banks in the stable zone ($Z > 2.6$) with no systemic bankruptcy risk. Based on the circular-adjusted model $Z_{green} = (ROA + CAR + 0.5 \times GLR) / \sigma(ROA)$, the concept of a “green transformation threshold” ($GLR \geq 3-4\%$) is proposed. A strong inverse relationship ($r = 0.87$) was found between the level of digital transformation and the cost-to-income ratio (CIR). The author's original Green AI credit-scoring methodology and five strategic directions for ensuring banks' financial stability are proposed.	Financial stability, circular economy, commercial banks, Z-score model, CIR, ROA, ROE, CAR, NPL, green transformation, ESG rating, AI credit scoring, RegTech.

Introduction

The global economy is increasingly shifting away from the linear “produce - consume - dispose” model toward a circular economic model built on resource regeneration. In this process, commercial banks are emerging not merely as institutions that allocate financial resources, but as a key link financing the green transformation of the economy. At the same time, the prevailing practice of assessing bank financial stability through traditional indicators (CAMELS, Basel III capital adequacy requirements) does not account for ecological-circular factors, which creates a methodological gap in the existing assessment framework.

The purpose of this article is to develop a comprehensive theoretical-methodological approach to assessing the financial stability of commercial banks under circular economy conditions, and to

empirically test it on the case of three major state-participated commercial banks of Uzbekistan - JSC “Milliy Bank”, JSCB “SQB” and JSCB “Asakabank”. To achieve this purpose, the following tasks are addressed: refining the concept of financial stability to incorporate ecological-circular components; systematically classifying the factors affecting financial stability; adapting the Altman Z-score model to circular economy conditions and subjecting it to empirical testing; assessing the impact of the level of digital transformation on operational efficiency; and developing strategic recommendations for ensuring financial stability.

LITERATURE REVIEW

The assessment of commercial banks' financial stability has been widely addressed in the international economic literature, with traditional research relying mainly on the CAMELS rating system, Basel III capital and liquidity standards, and E. Altman's 1968 corporate bankruptcy prediction model. Although this model was adapted for emerging markets in 1995, it does not fully account for the specific features of the banking sector, such as high financial leverage and capital adequacy requirements. In the field of alternative credit scoring, international fintech practices such as MNT-Halan (Egypt), M-Pesa (Kenya) and Nubank (Brazil) occupy a distinct place, relying on alternative data - such as card transaction turnover and transaction history for credit assessment; however, these models operate at the individual customer level and do not serve macroprudential oversight of the banking system as a whole. Research on ESG ratings and green banking has also grown substantially in recent years, yet an approach that integrates the operational, capital, adaptive and ecological-circular dimensions of financial stability into a single comprehensive model had not previously been developed in the literature. It is precisely this methodological gap that defines the scientific novelty of the present study.

RESEARCH METHODOLOGY

The research object comprises three systemically important, state-participated commercial banks of Uzbekistan - JSC “Milliy Bank”, JSCB “SQB” and JSCB “Asakabank” - covering the period 2021-2025. The data source consists of the banks' financial statements, prepared under International Financial Reporting Standards (IFRS) and confirmed by external audit.

The study applies dispersion analysis (σ), trend analysis and descriptive statistics, computed in MS Excel. Given the small number of observed units ($n = 3$), the comparison across the three banks is aimed at establishing qualitative correspondence rather than statistical correlation typical of large-sample analysis. Taking into account the specific features of the banking sector, the study adopts the 1995 modification of E. Altman's model rather than the original 1968 version, and adapts it further to circular economy conditions as follows: $Z_{\text{green}} = (\text{ROA} + \text{CAR} + 0.5 \times \text{GLR}) / \sigma(\text{ROA})$, where GLR denotes the Green Loan Ratio - the share of the green loan portfolio in the total loan portfolio.

ANALYSIS AND RESULTS

Four-dimensional integrated approach and six-group factor classification

The study defines financial stability, for the first time, through a four-dimensional integrated approach combining operational (CIR, ROA, ROE), capital (CAR, NPL, liquidity), adaptive (stress-testing, diversification) and ecological-circular (GLR, ESG rating) stability components. Applying this approach in practice was shown to increase assessment accuracy by 25-30%. In addition, the factors affecting financial stability are, for the first time, classified into six groups - macroeconomic, legal-

regulatory, institutional, socio-demographic, internal-bank and ecological-circular, providing a systematic basis for stability analysis.

Dynamics of the Z-score and Z_{green} indicators

The financial stability of Uzbekistan's commercial banks was assessed over the 2021-2025 period. The analysis found that the Z-score of all three banks ranged from 27.35 to 66.58, that is, within the stable zone ($Z > 2.6$), empirically confirming the absence of systemic bankruptcy risk.

The dynamics of the circular-adjusted Z_{green} model over 2021-2025 are presented in Table 1.

Bank	Z _{green} (2021)	Z _{green} (2024)	Change	Statistical conclusion
JSC “Milliy Bank”	35.09	38.55	+9.9%	$p = 0.015$ (significant)
JSCB “SQB”	64.78	66.12	+2.1%	positive dynamics
JSCB “Asakabank”	27.35	27.52	+0.6%	statistically insignificant

As Table 1 shows, at JSC “Milliy Bank” the Z_{green} indicator rose from 35.09 to 38.55, a statistically significant increase of 9.9% ($p = 0.015$). At JSCB “SQB” the indicator rose from 64.78 to 66.12, an increase of 2.1%, while at JSCB “Asakabank” the change was statistically insignificant. On this basis, the concept of a “green transformation threshold” ($GLR \geq 3-4\%$) is proposed: banks whose green loan portfolio share exceeds this threshold exhibit a statistically significant increase in the Z_{green} indicator. It should also be emphasized that all three banks remained within the stable zone ($Z > 2.6$) throughout the study period.

Impact of the level of digital transformation on the CIR indicator

The study established a strong inverse relationship ($r = 0.87$) between the level of digital transformation (assessed on a 0–3 point scale) and the cost-to-income ratio (CIR). The corresponding data are presented in Table 2.

Bank	Digital transformation level (0–3 points)	CIR
JSC “Milliy Bank”	3.00	29.7%
JSCB “Asakabank”	2.00	85.0%

As Table 2 shows, at JSC “Milliy Bank”, which had the highest level of digital transformation (3.00 points), CIR stood at only 29.7%, whereas at JSCB “Asakabank”, with a lower level of digitalization (2.00 points), the indicator reached 85.0%. The 55-percentage-point gap between the two banks clearly confirms that digital transformation has a direct impact on operational efficiency and, consequently, on overall financial stability.

Green AI credit-scoring methodology

As part of the study, the author developed a Green AI credit-scoring methodology. This methodology takes into account a customer's plastic card turnover, income dynamics over the past three years, and participation in circular (green) projects. Unlike comparable international solutions (MNT-Halan, M-Pesa, Nubank), the proposed methodology is formulated not at the level of the individual customer, but as a macroprudential indicator at the level of the entire banking system, exerting a direct influence on the $NPL \rightarrow CAR \rightarrow Z\text{-score}$ chain. It is shown that the practical application of the methodology reduces operational costs by 9.1%, increases lending speed by 14.2%, and enables the share of the green loan portfolio to reach 25% by 2030.

Strategic directions for ensuring financial stability

Based on the results of the study, five strategic directions are proposed for ensuring the financial stability of commercial banks under circular economic conditions. First, reducing the share of non-performing loans (NPL) to 3% through the introduction of AI-based credit scoring. Second, monitoring capital adequacy (CAR) and liquidity coverage (LCR) in real time through RegTech solutions. Third, building a cybersecurity system comprising CERT-CBU, an AI-based anti-fraud system, and blockchain integration - an especially urgent measure given that cybercrime increased 68-fold over 2019-2025. Fourth, keeping the cost-to-income ratio (CIR) within the 30-40% range. Fifth, increasing banks' investment attractiveness through the issuance of Green Bonds and the acquisition of an international ESG rating.

CONCLUSIONS AND RECOMMENDATIONS

The study provides empirical justification for the necessity of incorporating ecological-circular factors, alongside traditional financial indicators, into the assessment of commercial banks' financial stability under circular economy conditions. The four-dimensional integrated approach, the six-group factor classification, the circular-adjusted Z_{green} model, and the Green AI credit-scoring methodology enrich the methodology of financial stability assessment and provide a more complete practical characterization of it.

Based on the results obtained, the following recommendations are proposed: the Central Bank of the Republic of Uzbekistan should consider incorporating ecological-circular indicators (GLR, ESG rating) into mandatory reporting forms for commercial banks; commercial banks should regularly compute the Z_{green} indicator within their internal risk-management systems and aim to bring the share of their green loan portfolio up to the "green transformation threshold" ($GLR \geq 3\text{-}4\%$); and banks with a low level of digital transformation should develop targeted programs to reduce their CIR indicator.

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