ENHANCING STRESS-TESTING FRAMEWORKS IN COMMERCIAL BANKS: INTEGRATING MACROECONOMIC SHOCKS AND MACHINE LEARNING MODELS IN EMERGING MARKETS

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Abstract

This thesis explores ways to enhance stress-testing frameworks in commercial banks by integrating macroeconomic shocks and machine learning (ML) models in emerging markets. Based on an analysis of Basel III supervisory standards, Presidential Decree No. DP-5992, and scholarly literature, it is shown that while traditional linear stress tests are established, they fail to capture non-linear macro-financial tail risks and high-dimensional borrower default dynamics. A conditional sequence for implementation, the "macroeconomic shock vector – hybrid ML credit-loss engine – explainable AI (XAI) capital trigger" principle, and five readiness assessment indicators are substantiated.

Keywords: commercial banks, stress-testing framework, macroeconomic shocks, machine learning models, emerging markets, explainable AI, capital adequacy.

TIJORAT BANKLARIDA STRESS-TESTLASH TIZIMLARINI TAKOMILLASHTIRISH: RIVOJLANAYOTGAN BOZORLARDA MAKROIQTISODIY SHOKLAR VA MASHINALI O‘QITISH MODELLARINI INTEGRATSIYALASH

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Annotatsiya. Mazkur tezisda rivojlanayotgan bozorlarda makroiqtisodiy shoklar

va mashinali o‘qitish (ML) modellarini integratsiyalash orqali tijorat banklarida stress-testlash tizimlarini takomillashtirish yo‘llari tadqiq etilgan. Bazel III standartlari, PF-5992-son Farmon va ilmiy manbalar tahlili asosida an’anaviy chiziqli stress-testlar joriy etilgani, biroq ular nochiziqli makro-moliyaviy shoklar va qarz oluvchilar defoltining ko‘p o‘lchovli dinamikasini to‘liq qamrab olmasligi ko‘rsatilgan. Joriy etishning shartli ketma-ketligi, «makroiqtisodiy shok vektori – gibrid ML kredit zarari modeli – tushuntiriluvchi sun’iy intellekt (XAI) kapital signali» tamoyili hamda tayyorgarlikni baholovchi beshta ko‘rsatkich asoslab berilgan.

Kalit so‘zlar: tijorat banklari, stress-testlash tizimi, makroiqtisodiy shoklar, mashinali o‘qitish modellari, rivojlanayotgan bozorlar, tushuntiriluvchi sun’iy intellekt, kapital yetarliligi.

СОВЕРШЕНСТВОВАНИЕ СИСТЕМ СТРЕСС-ТЕСТИРОВАНИЯ В КОММЕРЧЕСКИХ БАНКАХ: ИНТЕГРАЦИЯ МАКРОЭКОНОМИЧЕСКИХ ШОКОВ И МОДЕЛЕЙ МАШИННОГО ОБУЧЕНИЯ НА РАЗВИВАЮЩИХСЯ РЫНКАХ

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Аннотация. В данных тезисах исследованы пути совершенствования систем стресс-тестирования в коммерческих банках путем интеграции макроэкономических шоков и моделей машинного обучения (ML) на развивающихся рынках. На основе анализа стандартов Базель III, Указа № УП-5992 и научных источников показано, что традиционные линейные стресс-тесты внедрены, но не учитывают нелинейные макрофинансовые шоки и многомерную динамику дефолтов заемщиков. Обоснованы условная последовательность внедрения, принцип «вектор макроэкономического шока – гибридная ML-модель кредитных потерь – триггер капитала на базе объяснимого ИИ (XAI)» и пять

показателей оценки готовности.

Ключевые слова: коммерческие банки, система стресс-тестирования, макроэкономические шоки, модели машинного обучения, развивающиеся рынки, объяснимый ИИ, достаточность капитала.

INTRODUCTION

Enhancing stress-testing frameworks by integrating macroeconomic shocks and machine learning (ML) models forms a forward-looking analytical framework for capturing non-linear default contagion, regime shifts, and structural vulnerabilities in emerging market commercial banks [Hull 2023: p. 478]. The Basel Committee on Banking Supervision (BCBS) mandates that stress-testing methodologies evolve to reflect complex risk interactions, requiring banks to validate advanced quantitative models and link shock projections directly to capital governance [BCBS 2018].

In Uzbekistan, an emerging market undergoing rapid financial transformation, the Strategy for Reforming the Banking System for 2020–2025 approved by Presidential Decree No. DP-5992 prioritized the transition to Basel III standards, the digitalization of credit underwriting, and the deployment of automated risk management systems [DP-5992 2020]. Simultaneously, the surge in digital banking platforms and financial technologies has generated high-dimensional borrower data, heightening the need for machine learning analytics alongside macroeconomic stress modeling [Elmirzayev et al. 2023: p. 236; Jiyanova 2022: p. 14].

However, conventional stress-testing frameworks in emerging markets rely heavily on linear econometric regressions and static sensitivity rules, which often fail during structural economic transitions and external shocks. In practice, commercial banks evaluate macroeconomic shocks—commodity price swings, exchange-rate depreciation, and inflation surges—separately from granular transactional and behavioral borrower data, overlooking non-linear threshold effects on probability of

default (PD) and loss given default (LGD) [Hull 2023: p. 492; Jiyanova 2022: p. 16]. Furthermore, black-box ML algorithms frequently lack supervisory interpretability and are not linked to Internal Capital Adequacy Assessment Process (ICAAP) triggers [BCBS 2018]. Consequently, the primary bottleneck lies not in algorithmic availability, but in model-risk governance, hybrid macro-ML integration, and explainable data infrastructure.

The objective of this research is to substantiate priority institutional tasks and practical directions for enhancing commercial bank stress-testing frameworks in emerging markets by integrating macroeconomic shocks and machine learning models, and to develop readiness assessment indicators. To achieve this objective, Basel III guidelines, Presidential Decree No. DP-5992, and contemporary banking literature were analyzed. The research results are as follows.

First, the institutional foundation for macro-ML stress testing in emerging market banks is substantiated across four core elements: a clear model-risk accountability chain (Supervisory Board Risk Committee, ALCO, independent Model Validation and AI Governance Division, and Internal Audit); a unified feature store combining macroeconomic series with granular borrower transactional data; substantive alignment of ML stress outputs with ICAAP and supervisory explainability standards; and specialized data science staff capacity [DP-5992 2020; BCBS 2018]. A "conditional sequence" is proposed: a commercial bank transitions to production macro-ML stress testing once these four institutional elements are established.

Second, for methodological integration and predictive accuracy, the "macroeconomic shock vector – hybrid ML credit-loss engine – explainable AI (XAI) capital trigger" principle is proposed: top-down macroeconomic shock scenarios (GDP contraction, exchange-rate depreciation, and interest rate hikes) are fed into gradient-boosted decision trees and neural networks trained on borrower-level cash-flow features

across a 4-to-8-quarter horizon [Elmirzayev et al. 2023: p. 268]. Non-linear PD and LGD migrations are tested across baseline, adverse, and severe emerging-market contagion scenarios, while Shapley Additive Explanations (SHAP) decompose each capital shortfall projection into transparent risk drivers, flagging unvalidated black-box outputs as "unverified" [Hull 2023: p. 508].

Third, five quantitative indicators measuring the readiness of a bank's integrated macro-ML stress-testing framework are proposed: the share of credit and market portfolios evaluated by hybrid macro-ML models benchmarked against linear baselines; the out-of-sample predictive gain under stress (Area Under the ROC Curve – AUC-ROC improvement of at least 8 percentage points [Hull 2023: p. 511]); the share of feature-store data pipelines updated automatically in real time; the share of ML stress scenarios audited via XAI metrics and linked to ICAAP buffer actions; and the share of quarterly model-drift reports reviewed by the Risk Committee. Achieving at least 75 percent automated feature-pipeline and XAI-validated model coverage is proposed by the author as a threshold condition requiring empirical pilot testing.

Fourth, a mechanism linking hybrid macro-ML stress test outputs to commercial bank decision-making is proposed: an interactive "Macro-ML Stress and Explainability Dashboard" is maintained within the bank's enterprise risk system, and XAI-attributed post-shock capital projections are mandatorily attached to Credit Committee and ALCO decisions on dynamic credit scoring cut-offs, sectoral limits, and capital buffer allocation. This mechanism operationalizes the BCBS requirement that advanced stress testing directly inform strategic solvency management [BCBS 2018; DP-5992 2020].

CONCLUSION

In conclusion, in our view, enhancing stress-testing frameworks in emerging market commercial banks requires shifting the focus from rigid linear extrapolations to building an institutional model-governance chain and a hybrid analytical architecture

that links macroeconomic shock scenarios with explainable machine learning models. Although Basel III standards and banking reform measures have established the legal foundation [DP-5992 2020], ML analytics and macroeconomic stress tests often remain disconnected from operational capital allocation decisions [BCBS 2018]. The research achieved its objective: a conditional implementation sequence, a hybrid modeling principle, and five readiness indicators were substantiated.

The findings rely on regulatory and secondary empirical analysis, while the proposed 75 percent automated feature-pipeline and XAI-validation threshold represents an authorial recommendation to be tested across several commercial banks in future research. Implementing these indicators will transform commercial bank stress testing into a proactive, interpretable, and resilient process.

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