Scenario-Based Macroeconomic and Financial Forecasting Using Quantum-Enhanced Models

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***Abstract*—Macroeconomic and financial forecasting plays a central role in policy design, risk management, and capital allocation, yet traditional econometric and machine learning models often struggle with nonlinear dynamics, structural breaks, and high-dimensional uncertainty. This paper explores scenario-based macroeconomic and financial forecasting using quantum-enhanced models, examining how hybrid quantum–classical frameworks can improve predictive performance under complex and volatile conditions. By integrating quantum optimization, probabilistic sampling, and high-dimensional feature mapping with scenario analysis techniques, the study proposes an architecture for modeling systemic risk, regime shifts, and tail-event dynamics. The analysis evaluates theoretical advantages, computational constraints, and implementation challenges within the Noisy Intermediate-Scale Quantum (NISQ) era. The findings suggest that quantum-enhanced forecasting may complement classical approaches by expanding solution space exploration and enhancing scenario sensitivity, thereby contributing to more resilient macro-financial decision-making systems.**

Forecasting macroeconomic and financial variables is inherently complex due to structural interdependencies, stochastic volatility, and regime-dependent dynamics. Policymakers, central banks, investment institutions, and multinational corporations rely on predictive models to anticipate inflation trajectories, interest rate movements, credit risk exposure, asset price fluctuations, and systemic crises [1]. However, traditional econometric models—such as vector autoregressions (VAR), dynamic stochastic general equilibrium (DSGE) models, and GARCH-type volatility frameworks—often encounter limitations when confronted with high-dimensional datasets and nonlinear feedback loops. Financial markets, in particular, exhibit non-stationarity, abrupt regime shifts, and fat-tailed distributions that challenge classical forecasting assumptions [2].

Scenario-based forecasting has emerged as a complementary methodology to conventional point predictions [10]. Instead of producing single-path forecasts, scenario analysis evaluates multiple plausible future trajectories based on varying macroeconomic conditions, policy interventions, or exogenous shocks. This approach is particularly

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relevant in environments characterized by uncertainty and structural transformation, such as climate-related risk, geopolitical instability, or technological disruption [3]. However, generating and evaluating large-scale scenario trees with high-dimensional state variables can be computationally intensive, often requiring advanced optimization and probabilistic modeling techniques.

The advent of quantum computing introduces alternative computational paradigms that may enhance scenario-based forecasting [6]. Quantum systems leverage principles such as superposition and entanglement to encode information in exponentially large Hilbert spaces. In theory, this enables more efficient exploration of complex probability distributions and combinatorial solution spaces. Quantum-enhanced models, particularly in hybrid quantum–classical architectures, integrate quantum subroutines—such as amplitude amplification, quantum annealing, or variational circuits—within classical forecasting pipelines [7]. These subroutines can potentially improve optimization efficiency, probabilistic sampling, and feature transformation in high-dimensional financial datasets.

Hybrid quantum–classical models are especially promising in the current NISQ era, where hardware limitations constrain fully quantum computations. In such frameworks, classical algorithms manage data preprocessing, parameter estimation, and macroeconomic calibration, while quantum components address computational bottlenecks related to nonlinear optimization or scenario generation [9]. For instance, quantum-enhanced Monte Carlo simulations may accelerate the estimation of tail-risk measures such as Value at Risk (VaR) and Expected Shortfall (ES), while quantum kernel methods can improve classification of financial regimes in noisy datasets.

From a macroeconomic perspective, quantum-enhanced models may contribute to improved analysis of systemic interconnections among financial institutions, supply chains, and global markets [8]. Network-based representations of economic systems often involve high-dimensional adjacency matrices and complex feedback dynamics. Quantum algorithms designed for graph optimization and sampling could facilitate the identification of contagion channels, resilience thresholds, and structural vulnerabilities within interconnected financial systems [5]. This capacity aligns with the growing emphasis on stress testing and forward-looking risk assessment in central banking and regulatory practice.

Despite these theoretical advantages, significant practical and conceptual challenges remain. Quantum hardware noise, limited qubit counts, and error propagation constrain model scalability and reliability [4]. Moreover, integrating quantum outputs into established econometric frameworks requires methodological transparency and interpretability to ensure policy relevance. The adoption of quantum-enhanced forecasting models also raises governance considerations related to model validation, risk accountability, and technological inequality among institutions.

This paper investigates scenario-based macroeconomic and financial forecasting using quantum-enhanced models, emphasizing their potential to complement classical econometric techniques in high-uncertainty environments. By analyzing hybrid architectures, computational trade-offs, and application domains, the study situates quantum-enhanced forecasting within the broader evolution of financial analytics. Ultimately, the integration of quantum computation into macro-financial modeling reflects a broader transition toward computationally intensive, data-driven decision systems designed to navigate increasingly complex global economic landscapes.

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