

Modeling Macroeconomic Output Gains from Quantum-Driven Productivity: Scenario-Based Forecasts

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Abstract—Emerging advances in quantum computing have raised significant expectations regarding their potential to accelerate computational processes and transform productivity across multiple industries. While most existing research focuses on micro-level applications such as optimization, cryptography, and materials discovery, the broader macroeconomic implications of quantum-driven productivity remain underexplored. This paper investigates modeling macroeconomic output gains from quantum-driven productivity using scenario-based forecasts, examining how the diffusion of quantum technologies could influence economic growth, sectoral productivity, and global competitiveness. By integrating scenario analysis with computational economic modeling, the study evaluates potential productivity pathways under varying technological adoption rates, infrastructure readiness, and policy environments. The analysis highlights both the opportunities and uncertainties associated with quantum technology diffusion, emphasizing the role of innovation ecosystems, investment strategies, and regulatory frameworks in shaping macroeconomic outcomes. The findings suggest that while quantum technologies may generate substantial productivity gains in the long term, their macroeconomic impact will depend on complementary investments in digital infrastructure, human capital, and technological governance.

■ Technological innovation has historically served as one of the primary drivers of economic growth and productivity improvements. From the mechanization of industrial production to the digital transformation of modern economies, breakthrough technologies have repeatedly reshaped production processes, labor markets, and global competitive dynamics [9]. In recent years, quantum computing has emerged as a potentially transformative technological frontier

with the capacity to redefine computational limits and accelerate problem-solving capabilities across scientific, industrial, and financial domains [1].

Quantum computing differs fundamentally from classical computing in its use of quantum mechanical principles such as superposition and entanglement to process information. These properties allow quantum systems to represent and evaluate multiple computational states simultaneously, potentially enabling exponential speedups for certain classes of problems [4]. Applications in optimization, materials

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science, drug discovery, logistics, and financial modeling have already been widely discussed in the scientific literature. However, the broader macroeconomic consequences of these technological capabilities—particularly in terms of aggregate productivity and economic output—remain relatively underexamined [8].

Understanding the macroeconomic implications of quantum-driven productivity requires a shift from purely technical analyses toward interdisciplinary economic modeling. Productivity gains generated by advanced computational technologies can influence economic growth through several channels, including improvements in production efficiency, acceleration of innovation cycles, and the emergence of entirely new industries [6]. At the same time, the diffusion of such technologies is rarely uniform across sectors or regions. Differences in technological infrastructure, human capital availability, investment capacity, and regulatory environments shape how quickly and effectively new technologies translate into measurable economic benefits [2].

Scenario-based forecasting provides a useful framework for analyzing these dynamics under conditions of technological uncertainty. Unlike deterministic economic forecasts, scenario models explore multiple plausible future trajectories based on varying assumptions about technology adoption, policy interventions, and market conditions [3]. This approach is particularly relevant for emerging technologies such as quantum computing, where long-term impacts remain uncertain and depend heavily on research breakthroughs, industrial scaling, and global cooperation [5].

From a macroeconomic perspective, quantum computing may influence productivity through both direct and indirect mechanisms. Direct effects may arise from improved optimization in supply chains, energy systems, financial markets, and manufacturing processes [7]. Indirect effects may emerge through spillover innovations in artificial intelligence, materials science, and digital infrastructure [10]. These interactions can create multiplier effects that amplify the overall contribution of quantum technologies to economic output.

However, technological revolutions also generate

transitional challenges. The development of quantum computing infrastructure requires significant capital investment, specialized expertise, and international collaboration [11]. Moreover, disparities in technological access may exacerbate economic inequalities between countries or industries that adopt quantum technologies early and those that lag behind. Policymakers and economic institutions therefore face the dual challenge of fostering innovation while ensuring equitable and sustainable technological diffusion [12].

This paper examines potential macroeconomic output gains associated with quantum-driven productivity using scenario-based forecasting models. By integrating technological diffusion assumptions with macroeconomic productivity frameworks, the study explores how quantum computing could reshape economic performance across different development trajectories. Ultimately, understanding the macroeconomic implications of quantum technologies is essential for informing policy strategies, investment priorities, and global economic planning in the emerging era of quantum innovation.

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