

# The Quantum–AI Index (QAI): An Expressivity–Stability Metric for Hybrid Quantum Forecasting

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## Abstract

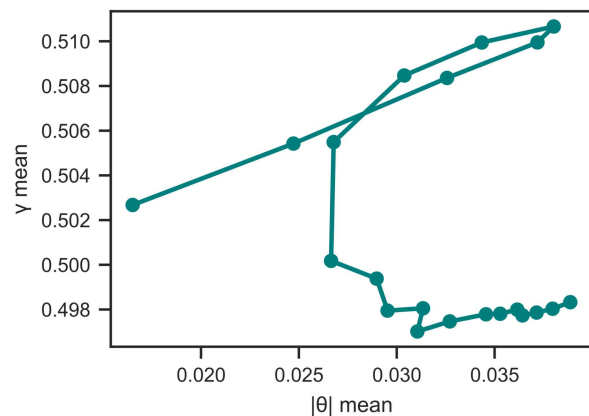
This extended abstract introduces the Quantum–AI Index (QAI), a composite functional designed to evaluate the trade-off between expressivity and training stability in hybrid quantum–classical forecasting architectures. As variational quantum circuits are integrated with classical temporal models, predictive accuracy alone becomes insufficient for assessing performance under near-term quantum resource constraints. Increasing circuit expressibility can induce gradient concentration and barren plateaus that degrade trainability [1], while data re-uploading enhances representational capacity through controlled depth expansion [2]. Motivated by this tension, QAI integrates predictive accuracy, gradient alignment between classical and quantum layers, and training variance into a unified expressivity–stability manifold. Rather than proposing a new architecture, this work emphasizes evaluation methodology for balanced hybrid design. Using temporally aggregated and anonymized traffic flow data, we illustrate how segmentation depth and quantum re-uploading intensity occupy distinct regions within the QAI landscape. Results indicate that marginal accuracy gains may coincide with increased gradient dispersion and reduced convergence robustness. Figure 1 depicts the conceptual geometry of the QAI manifold and representative allocation regimes. The proposed index provides a diagnostic framework for

identifying resource-efficient operating regimes in hybrid models under limited qubit counts and shallow circuit depths.

## References

- [1] J. R. McClean, S. Boixo, V. N. Smelyanskiy, R. Babbush, and H. Neven, *Nature Communications*, 9 (2018) 4812.
- [2] A. Pérez-Salinas, A. Cervera-Lierta, E. Gil-Fuster, and J. I. Latorre, *Quantum*, 4 (2020) 226.

## Figures



**Figure 1:** Conceptual QAI landscape depicting the trade-off between quantum parameter intensity ( $|\theta|$  mean) and predictive output ( $Y$  mean) across representative hybrid configurations.