Step 4

Experimental validation

Preparation

A. Datasets

Quarterly *macroeconomic data from five countries*

(China, Germany, Japan, the United Kingdom, & the United States)

B. Variables

Target *variables: real GDP growth*

Forecast *variables: inflation, unemployment*

Comparison Models

- **unitary-constrained** — QTFT
- **baseline** — TFT
- **deep learning** — LSTM
- **classical** — ARIMA

Forecast horizons and results

1-step	4-step	8-step
short-term	medium-term	long-term

QTFT significantly outperforms all baselines (at the 5% level)
Long-horizon error growth is smooth and monotonic

Step 5

Ablation experiments

Training stability

Convergence

Design efficiency

→ **Validation objectives**

Key validation

Placement	*Apply the unitary constraint immediately **after** variable selection to prevent error accumulation in subsequent nonlinear transformations.*
Depth	*Macroeconomic data samples are limited, and excessive parameters in deep models lead to overfitting (**shallow**).*
Para-meterization	***Product-gate decomposition** is optimal in terms of accuracy, parameter efficiency, and computational speed.*
Complex-valued vs. real-valued	*The phase degrees of freedom of **complex-valued** parameters can better capture the cyclical dynamics of economic cycles.*

Core results

Improved convergence speed of 72%

Reduced loss variance of 75%

Parameter overhead of only 4%

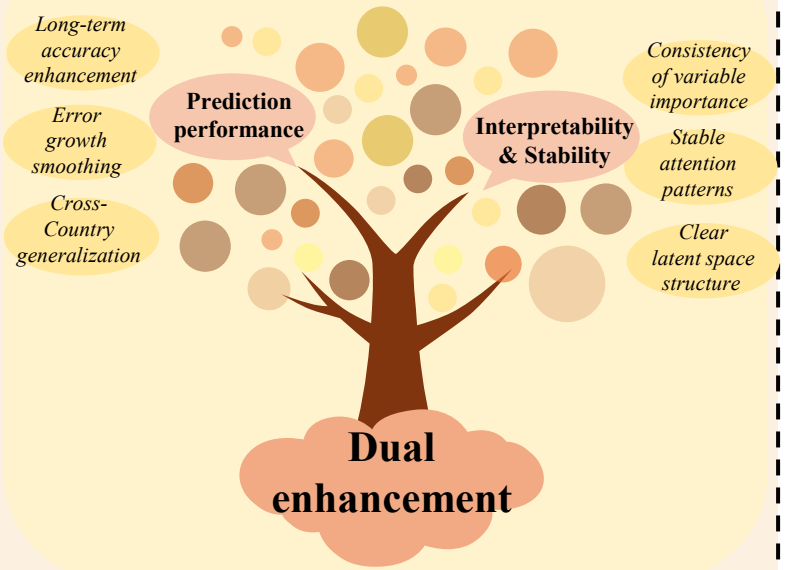
Step 6

Results

Core contributions

Geometric constrains → *Robustness* + *Interpretability*

Without sacrificing expressive power



Application value

I. Policy-relevant forecasting

II. Bridging flexible ML with policy stability requirements