**Traditional Deep Learning** — *Unconstrained Representations*

**QTFT (This Work)** — *Unitary Constraints*

**Adaptive QTFT (Future)** — *Regime-dependent Geometry*

## ✓ Core Contributions (Validated)

1. **Representation Stability**
   Eliminates drift across time steps & horizons
2. **Long-horizon Coherence**
   Smooth error accumulation in multi-step forecasts
3. **Gradient Stability**
   Prevents vanishing/exploding gradients, fast convergence
4. **Interpretability**
   Stable variable importance rankings across runs

Enables

**QTFT**
Unitary Transformation

Constrains

## ! Current Limitations

- **Magnitude Constraint**
  Cannot encode uncertainty through representation norm
- **Fixed Geometry**
  Single unitary matrix across all regimes
- **Cross-country Homogeneity**
  Insufficient heterogeneity across economies

## Future Research Directions

- **F1 — Adaptive Constraints**
  Regime-dependent unitary strength
- **F2 — Network Integration**
  Explicit cross-country interaction structures
- **F3 — Probabilistic Extension**
  Uncertainty decomposition & norm dynamics
- **F4 — Theoretical Foundation**
  Open quantum systems & information theory