The Hong Kong University of Science and Technology

Department of Mathematics

MPhil THESIS EXAMINATION

Portfolio Optimization with Directional References and Market-State Conditioning in Crypto Markets

By

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ABSTRACT

Cryptocurrency portfolio construction is challenging due to high volatility, strong non-stationarity, rapid regime shifts, limited effective samples, and transaction frictions. In this setting, classical mean-variance methods remain sensitive to noisy return and risk estimates, rigid two-stage predict-then-optimize pipelines are prone to objective mismatch and error amplification, and conventional end-to-end portfolio learning often depends primarily on raw return sequences without explicit directional guidance.

This thesis first conducts a unified empirical assessment of three major method families for cryptocurrency portfolio optimization: classical mean-variance benchmarks, two-stage predict-then-optimize methods, and end-to-end portfolio learning baselines. The comparison clarifies their performance boundaries and characteristic failure modes under a common rolling backtest protocol. Motivated by these findings, this thesis proposes Method D, a conditioned two-stage portfolio learning framework. In Method D, Stage 1 produces a cross-sectional return forecast that is used as a directional reference rather than a direct plug-in estimate for a fixed optimizer. Stage 2 then learns portfolio weights under a portfolio-level mean-variance objective by jointly incorporating three sources of information: historical return dynamics, the directional reference from Stage 1, and a small set of market-state factors. This design preserves directional information from forecasting while reducing reliance on rigid analytical mapping and improving the use of heterogeneous information in portfolio construction.

Backtests, cross-backbone comparisons, and controlled ablation studies show that Method D consistently outperforms traditional mean-variance, rigid two-stage, and end-to-end baseline families in risk-adjusted performance under the unified protocol. The ablation results further indicate that directional reference and market-state conditioning provide complementary gains, and that the attainable performance ceiling depends on the quality of the directional forecast. Taken together, the results support a portfolio-learning approach that combines adaptive weight generation with structured directional and market-state information in cryptocurrency markets.

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Venue : Room 4472 (Lifts 25-26)

Thesis Examination Committee

Chairman	**:**	**Prof. Yang XIANG, MATH /HKUST**
Thesis Supervisor	**:**	**Prof. Can YANG, MATH/HKUST**
Member	**:**	**Prof. Rong TANG, MATH/HKUST**

(Open to all faculty and students)

The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).