2025 Helmholtz – OCPC – Program

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Machine Learning-Enhanced Intraday Option Return Prediction and Autonomous Trading: A Dynamic Factor and Reinforcement Learning Approach

Helmholtz Centre and/or institute:

Karlsruhe Institute of Technology (KIT) Institute for Finance, Chair of Financial Economics and Risk Management

Project leader:

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Description of the project (max. 1 page)**:**

Machine learning (ML) offers significant advantages in processing high-dimensional data and modelling nonlinear relationships. By employing dimensionality reduction, variable selection, and regularization techniques, ML effectively addresses the challenges that traditional methods face in handling large numbers of variables and complex interactions. Therefore, in the first part of this study, we employ ML to construct linear, nonlinear, and ensemble models for predicting 30-minute intraday option returns.

Factor models are widely used in asset return research but face three major challenges in option return forecasting. First, traditional factor models rely on fixed analytical factors, whereas the complex nature of option returns makes it difficult for a single factor to comprehensively explain return variations. Second, the short lifecycle and dynamic characteristics of options make long-term time-series regression methods unsuitable. Third, these models assume a static beta, whereas option risk exposure is inherently dynamic, making static models inadequate for capturing risk characteristics accurately. To address these issues, the Instrumented Principal

Component Analysis (IPCA) model has been introduced. By dynamically adjusting the factor structure and employing conditional beta estimation (based on observable option characteristics), IPCA refines the static beta assumption and directly infers risk factors from the data, significantly improving prediction accuracy and flexibility. Building on this framework, the second part of our study develops a dynamic parameter optimization model that allows model parameters to adjust automatically over time and in response to option-specific characteristics, further enhancing predictive performance.

The third part of this study applies reinforcement learning (RL) to construct an autonomous trading system based on the forecasting results. RL continuously optimizes trading decisions through iterative market interactions without relying on pre-defined rules, with the objective of maximizing cumulative returns and risk-adjusted Sharpe ratios. Beyond adapting to market changes, RL integrates historical trading behaviour, transaction costs, and slippage into its decision-making process, effectively mitigating the risks associated with overtrading. As a result, RL offers an efficient, flexible, and intelligent trading solution.

Overall, this study consists of three key components: first, the application of various ML models to predict option returns and evaluate their effectiveness; second, the use of the IPCA framework and dynamic parameter optimization to address the limitations of fixed-parameter models in option return forecasting; and third, the integration of forecasting results into an RL-based autonomous trading system to advance intelligent option trading.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

We are offering collaboration in the field of big data analytics applied to financial markets. The Chinese collaborator shall have experience in big data work and interested in studying financial machine learning algorithms.

Required qualification of the postdoc:

- PhD in a quant discipline
- Experience with working with large datasets and mathematical algorithms
- Language requirement: good English skills