Vito Levstik

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**Committee for Student Affairs**

Univerza v Ljubljani, Fakulteta za računalništvo in informatiko

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# The master's thesis topic proposal
## Candidate: Vito Levstik

I, Vito Levstik, a student of the 2nd cycle study programme at the Faculty of computer and information science, am submitting a thesis topic proposal to be considered by the Committee for Student Affairs with the following title:

Slovenian: **Ocenjevanje volatilnosti z Markovskim prehajanjem na finančnih trgih s sekvenčnimi Monte Carlo metodami**
English: **Estimating Markov switching volatility in financial markets using sequential Monte Carlo methods**

This topic was already approved last year: *NO*

I declare that the mentors listed below have approved the submission of the thesis topic proposal described in the remainder of this document.

I would like to write the thesis in English with the following reason: It is encouraged to write the thesis in English for Data Science students, hence I would like to follow this recommendation.

I propose the following mentor:

Name, surname and title: izr. prof. dr. Jure Demšar
Institution: Fakulteta za računalništvo in informatiko, Univerza v Ljubljani
E-mail: jure.demsar@fri.uni-lj.si

Ljubljana, November 22, 2025.

## Key-words

Bayesian inference, sequential Monte Carlo, Markov switching models, financial time series, stochastic volatility

## Detailed thesis proposal

**Problem & State of the Art.** Understanding and forecasting financial market volatility is essential for risk management, portfolio allocation, and derivatives pricing [1]. Market volatility often exhibits sudden changes, alternating between low and high volatility regimes. Markov switching stochastic volatility (MSSV) models capture these dynamics by modeling latent volatility and discrete market regimes [2]. In such models, sequential Monte Carlo (SMC) methods are tools for estimating latent states [3], but many approaches rely on known parameters or simplified dynamics [4–6]. Full Bayesian inference that jointly estimates latent states and all model parameters is less commonly implemented, particularly for real-world financial time series, leaving scope for methodological development and empirical evaluation.

**Expected Contributions / Technical outcome.** This thesis will develop a Bayesian inference framework for MSSV models using SMC methods. The main contributions are: (1) the implementation of Bayesian inference framework using PMCMC [7] and $SMC^2$ [8] to jointly infer latent volatility, regime states, and model parameters; (2) a comparison of SMC-based inference with conventional MCMC methods; and (3) an analysis on equity and cryptocurrency data evaluating the forecasting performance of MSSV models relative to standard volatility benchmarks such as GARCH [9].

**Methodology & Validation.** The methodology will be implemented in Python and validated using both simulated and real financial time series. Performance of SMC methods will be evaluated against conventional MCMC methods, with a focus on computational cost and estimation efficiency. In addition, the MSSV model's forecasting ability will be compared to standard volatility models such as GARCH, using realized volatility as the benchmark.

## References

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