MS-E2177 Project Plan: State Treasury

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January 2026

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1 Introduction

The purpose of this project is to develop a simple, analytical, and decision-relevant framework for assessing the risks associated with the Finnish central government debt portfolio. This type of framework is crucial when the main objective is to ensure that the government's financing needs and payment obligations are met at the lowest possible cost consistently while maintaining controlled exposure to risk. The project is carried out in collaboration with the State Treasury and the end product is designed to support strategic decision-making under macroeconomic uncertainty.

This case study focuses on interest rate risk in a broad sense: the risk that the interest burden and debt dynamics evolve materially less favorably than planned. This can manifest as (i) higher near-term debt servicing costs, (ii) a persistent increase in the average cost of funding as higher rates pass through refinancing, and (iii) weaker medium-term fiscal sustainability through an adverse interest–growth differential. These mechanisms are captured by the debt accumulation identity, where the interest–growth differential plays a central role over longer horizons.

The operating environment for Finnish central government debt management has changed materially since the early 2000s. Public debt relative to GDP has risen substantially, contingent liabilities have expanded, and structural factors such as population ageing and weak productivity growth constrain medium-term growth prospects. These dynamics reduce fiscal space and weaken the state's capacity to absorb macro-financial shocks.

The project will develop an analytical framework to quantify how alternative interest rate risk strategies affect (a) the debt-to-GDP path and (b) the level and variability of debt servicing costs under scenarios for interest rates, GDP, inflation, and fiscal balances. The model should incorporate correlations and feedback effects among key variables, stress test robustness to macro-financial-fiscal shocks, and allow explicit constraints on acceptable refinancing risk, refinancing costs, and market execution feasibility. The framework can build on the risk-based sovereign financing approach of Zenios et al. (2021).

The State Treasury and the Ministry of Finance will provide data and support in assumptions and model design. Team members are expected to follow confidentiality requirements and sign a non-disclosure agreement as required.

2 Project objective

The primary objective is to build a simulation-based framework that allows the assessment of:

- interest rate risk
- refinancing and funding risk
- debt sustainability
- use of derivatives strategies

in an uncertain macroeconomic environment. The emphasis is on interpretability, transparency, and practical usability rather than maximal technical complexity.

3 Key modelling requirements

The framework should allow control over and interpretation of the following high-level parameters:

1. average level of interest rates
2. average term premium

3. dependence between short and long interest rates
4. lower and upper bounds on interest rates, including the frequency of boundary events
5. relationship between interest rates and macroeconomic variables such as GDP, government deficit, and inflation
6. volatility characteristics, including variability across time horizons and speed of mean reversion

4 Guiding principles

The project follows the principles below:

- **Start small, keep it simple**: the framework is built incrementally, beginning with a minimal viable structure.
- **Roughly right rather than precisely wrong**: realism and robustness are prioritized over overfitting or excessive model complexity.
- **Decision-ready outputs**: results must be interpretable and suitable for strategic policy and risk discussions.
- **Risk as distributions**: risks are analyzed using full distributions rather than point estimates, with particular attention to tail risk.

5 Data

5.1 Data sources

The analysis is based on historical time series of:

- interest rates at selected maturities
- macroeconomic indicators relevant for public debt dynamics

5.2 Data preparation

Data preparation includes:

- alignment of different data frequencies
- treatment of missing observations
- basic transformations and consistency checks

6 Current project scope

At the current stage, the project focuses on:

- constructing a baseline simulation framework
- modeling macroeconomic dynamics in a simplified form
- estimating key statistical properties from historical data to support scenario generation

More advanced components such as derivatives, optimization routines, and complex feedback mechanisms are explicitly left for later development phases.

7 Model architecture

The analytical framework is structured as a modular system consisting of two main components:

1. a stochastic interest rate engine
2. a debt management engine

The two components are designed to be conceptually separated but tightly coupled through scenario-based inputs and outputs.

7.1 Stochastic interest rate engine

The purpose of the stochastic interest rate engine is to generate economically plausible interest rate scenarios under macroeconomic uncertainty. It serves as the primary source of uncertainty in the framework.

The engine is required to produce scenarios that allow control over and interpretation of the following characteristics:

- the average level of interest rates
- the average term premium
- the dependence between short and long maturities
- lower and upper bounds on interest rates, including the frequency of boundary events
- the relationship between interest rates and macroeconomic variables such as GDP, government deficit, and inflation
- volatility properties, including variability across time horizons and the speed of mean reversion

The emphasis is on realistic joint dynamics and interpretable scenario behavior rather than exact replication of historical time series.

7.2 Debt management engine

The debt management engine maps interest rate and macroeconomic scenarios to fiscal outcomes and risk measures. It contains a representation of the central government debt portfolio and alternative debt management strategies.

Key elements of the debt management engine include:

- the current debt stock and its maturity structure
- refinancing strategies and issuance policies
- the use of derivatives for interest rate risk management
- cash flow generation and debt servicing costs under different scenarios

The engine enables the comparison of alternative strategies in terms of cost, risk, and sustainability across the simulated scenarios.

7.3 Interaction between the engines

The stochastic interest rate engine produces scenario paths for interest rates and macroeconomic variables. These scenarios are used as inputs to the debt management engine, which evaluates their implications for refinancing risk, interest expenditure, and debt sustainability.

This modular architecture allows the two components to be developed, tested, and extended independently, while maintaining a clear and transparent interface between uncertainty generation and decision analysis.

8 Analysis and validation

The framework will be assessed through:

- comparison of simulated outcomes with historical behavior
- internal consistency and stability checks
- sensitivity analysis with respect to key assumptions

9 Project timeline

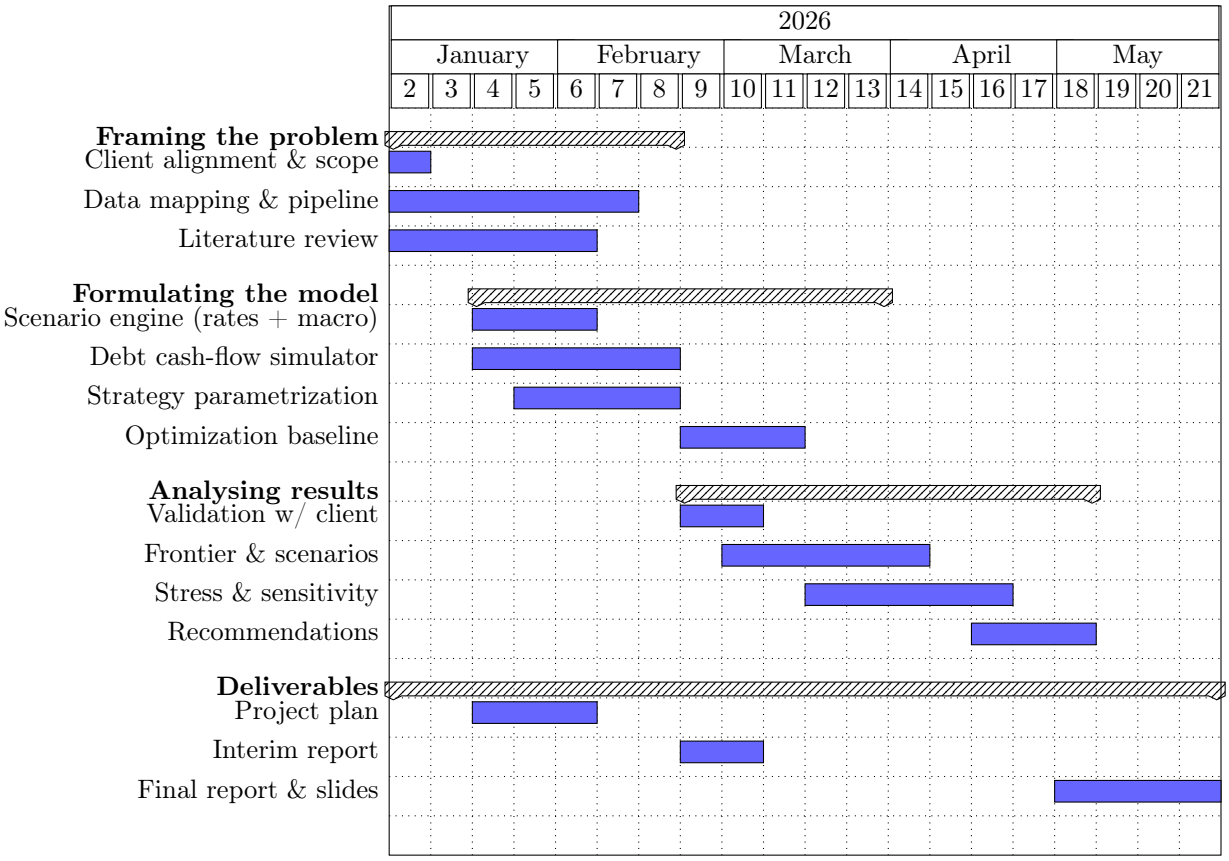

Figure 1: Initial project schedule.

10 Expected deliverables

The project will deliver:

- a documented analytical framework for interest rate and funding risk assessment
- comparable results across alternative scenarios and strategies
- a foundation for further development and potential decision support at the State Treasury

11 Limitations and risks

The main limitations relate to data availability, modeling uncertainty, and time constraints. These are addressed through transparent assumptions and clear documentation of model scope.

We anticipate the most relevant risks and define mitigation actions. Likelihood is assessed on the scale: Low (unlikely but possible), Medium (may occur), High (likely).

Table 1: Risk analysis and mitigation plan.

Risk	**Likelihood**	**Consequences**	**Mitigation**
Schedule risk / underestimation of workload	Medium	Delays in implementation or insufficient time for robustness and writing.	Time-box model versions (baseline → improved), weekly milestones, reserve buffer in May for writing and polishing.
Scope creep / objectives become too broad	Medium	Model becomes overly complex. Results remain incomplete or hard to interpret.	Lock MVP requirements early with client; explicitly defer "nice-to-have" features; maintain a scope backlog.
Data access delays (incl. NDA) or limited data granularity	Medium	Cannot calibrate/validate properly; results less credible.	Early NDA handling; create synthetic/placeholder pipeline; start with publicly available proxies; iterate when client data arrives.
Data quality / inconsistencies in legacy cash flows	Medium	Incorrect refinancing needs and cost calculations.	Systematic data checks; reconciliation against known aggregates; unit tests for cashflow engine; client validation checkpoints.
Model risk / misspecification (scenario dynamics, correlations)	High	Misleading risk estimates and strategy rankings.	Use multiple scenario specifications (VAR + stress overlays); sensitivity analysis; transparent assumptions; compare to stylized benchmarks.
Computational tractability (large scenario trees / optimization instability)	Medium	Solver issues; inability to run enough experiments.	Start with coarse scenarios; reduce dimensionality (PCA factors); adopt efficient risk constraints; caching and profiling.
Execution feasibility not reflected (market capacity, issuance constraints)	Medium	Recommendations infeasible in practice.	Explicit feasibility constraints (issuance bounds, smoothing); incorporate client rules of thumb; document implementability.
Interpretation risk (results too technical)	Medium	Client cannot use insights; weak final report narrative.	Use clear KPIs (fan charts, threshold breach probabilities); explain trade-offs; provide simple strategy summaries and "rules".
Team coordination risk / uneven workload	Medium	Bottlenecks and quality issues.	Clear task ownership; weekly internal sync; shared repo and coding standards; early integration of code modules.

References

1. Stavros A. Zenios, Andrea Consiglio, Marialena Athanasopoulou, Edmund Moshammer, Angel Gavilan, and Aitor Erce. "Risk Management for Sustainable Sovereign Debt Financing." *Operations Research*, 69(3):755–773, 2021. doi:10.1287/opre.2020.2055.