

Final Public Report

Consolidated Overview of the Public Reports by Module

Module 1 — Theoretical foundation and problem definition

The first module focused on building the **conceptual and methodological foundations** of the research. It established the central research problem related to the unpredictability of economic recessions, integrating economic theory (business cycles, crises, black swan events) with statistical and probabilistic principles.

Key advances included:

- Clear definition of the **research problem, general objective, and specific objectives**.
- Structured formulation of **null and alternative hypotheses**, including primary and secondary hypotheses.
- Careful selection of **macroeconomic variables** and definition of the research design (exploratory, quantitative, case study).
- Theoretical justification for the use of **Monte Carlo Simulation** as an appropriate approach for modeling non-linear and stochastic economic phenomena.

This module ensured **scientific coherence**, preventing the project from becoming purely technical without theoretical grounding.

Module 2 — Data analysis and first model implementation

In the second module, the project transitioned from theory to **empirical experimentation**, focusing on exploratory data analysis and the **first practical implementation of the Monte Carlo Simulation**.

The main advances were:

- Detailed statistical analysis of economic indicators (CLI, LEI, GDP per capita, GOM910, PCM910), identifying **outliers, asymmetries, and anomalous behavior**.
- Definition of **operational recession criteria**, based on historical quartiles and empirical indicator behavior.
- Development of an initial **Monte Carlo simulation engine**, capable of generating future trajectories based on historical shocks.
- Probabilistic estimation of recession likelihood for the **2008 financial crisis and the 2020 pandemic**, highlighting structural differences between financial crises and exogenous shocks.

This module demonstrated that **recessions are not deterministic events**, but probabilistic phenomena strongly dependent on context and time windows.

Module 3 — Methodological sophistication, comparison, and validation

The third module represented a significant methodological leap. The focus shifted from merely simulating outcomes to **evaluating, comparing, and critically validating the model**.

Major advances included:

- Development of a **complete modeling pipeline** integrating Probit regression, VAR(1), and Monte Carlo Simulation, explicitly modeling uncertainty.
- Systematic comparison of the Monte Carlo model with alternative approaches (Regression, Logistic Bootstrap, Markov Chains, and Threshold VAR).
- Evaluation using both classification and probabilistic metrics (Accuracy, Recall, F1-score, Brier Score, Log Loss).
- Application of **cross-validation, stress testing, and rolling validation**, revealing important limitations in generalization and temporal stability.
- Identification of **overfitting, deterministic behavior under stress scenarios**, and weak regime discrimination.

This module was critical in showing that **strong in-sample performance does not guarantee robustness**, reinforcing the importance of probabilistic calibration and

temporal validation in economic forecasting models.

Module 4 — Final consolidation and defense preparation

In the fourth module, the research focused on the final consolidation of the Undergraduate Thesis and on the strategic preparation for the thesis defense. All chapters were systematically reviewed to ensure textual cohesion, logical progression, and alignment between the research problem, methodology, results, and conclusions.

A thorough double check of all graphs, tables, and statistical outputs was conducted to ensure consistency between reported results and their interpretations. At this stage, special attention was given to unifying technical language, terminology, and objectives across chapters, eliminating redundancies and ambiguities.

In parallel, the oral presentation was developed following a clear narrative structure: problem → method → model → results → conclusions. Only the most essential visualizations were selected, prioritizing clarity and interpretability over excessive technical detail.

The preparation phase included timed rehearsals, adjustments in tone of voice, posture, pacing, and storytelling, as well as the anticipation of potential questions from the evaluation committee and the preparation of strategic responses. External feedback was requested and incorporated into the final version of the presentation.

After the official defense, the committee's recommendations and observations were systematically recorded, allowing the collection of valuable insights for both final refinements of the thesis and future research directions.

Conclusion of the Public Reports

The consolidation of the Public Reports reveals a coherent and progressively matured research trajectory. The project evolved from a solid theoretical foundation in Module 1, to careful empirical implementation in Module 2,

culminating in comparative analyses, rigorous validations, and critical reflections in Module 3.

The results demonstrate that Monte Carlo Simulation is a powerful tool for interpreting the randomness of economic recessions, particularly because it allows explicit modeling of uncertainty and temporal dependence among macroeconomic variables. However, the study also shows that probabilistic forecasts face important limitations, including calibration issues, sensitivity to extreme shocks, and challenges in out-of-sample generalization.

More than providing point predictions, the main contribution of this research lies in a paradigm shift: from deterministic forecasting toward a probabilistic and critical understanding of economic cycles. In this sense, recessions should not be treated as predictable binary events, but as complex, uncertain phenomena driven by multiple interconnected factors.

Taken together, the Public Reports consolidate a consistent academic contribution to the study of economic recession unpredictability, offering both methodological advances and relevant theoretical insights to guide future research.