Macro Risk Forecasting Package V1: Technical Overview

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Version note: This document describes the V1 baseline prototype for portfolio documentation and iterative model improvement.

1 What this folder is

This folder contains a complete, runnable macroeconomic forecasting package. It is designed to generate 20 years of quarterly U.S. macro projections that can feed into mortgage credit risk models (PD/LGD). It is *not* the PD model itself; it produces the macro inputs that PD models use.

2 What you can do with it

- Refresh U.S. macro data from public sources (FRED).
- Fit a short-term forecasting model that captures near-term dynamics.
- Extend forecasts to 20 years using explicit long-run assumptions.
- Produce multiple scenarios (baseline, mild adverse, severe adverse, demographic low growth).
- Export a small, PD-ready CSV with units and transformation labels.

3 Folder Structure

- `scripts/`: runnable programs that fetch data and generate forecasts.
- `data/`: the cleaned quarterly dataset used by the models.
- `outputs/`: all generated forecast outputs.
- `macro_engine_config.json`: configuration for model horizons, variables, and scenarios.
- `macro_engine_schema.md`: column definitions and units.
- `README_MACRO_ENGINE.md`: run instructions + auto-synced schema.

4 Detailed workflow

1. Data

- Pull 28 public macro series (labor, prices, activity, housing, credit, household balance sheet, demographics) via `fetch_macro_panel_fred.py`.
- Aggregate monthly series to quarterly averages; keep quarterly series as-is; compute YoY changes for growth/inflation series; and drop rows with missing variables.
- Save both the raw and modeled panels plus metadata: `data/macro_panel_quarterly_{raw,model}.csv` and `data/macro_panel_metadata.json`.

2. Short horizon (quarters 1–8)

- Fit a VAR on a stable 12-variable benchmark subset (unemployment, headline/core CPI, real GDP, HPI, housing starts, mortgage rates, 10y UST, HY spread, fed funds, delinquency, working-age population growth) for diagnostics and impulse responses.
- Fit a Minnesota-prior BVAR on the full 28-variable panel with hyperparameters $(\lambda_1, \lambda_2, \lambda_3, \lambda_4) = (0.2, 0.5, 1.0, 5.0)$. Short-horizon output defaults to this BVAR path unless configured otherwise.
- Simulate 600 draws from each model to capture 5/50/95 quantiles and write them to `macro_forecast_short_horizon_in`
- Export IRFs for mortgage-rate, HPI, and unemployment shocks for interpretation via `macro_impulse_responses.csv`.

3. Medium horizon (quarters 9–20)

- Compute an anchor vector from configuration assumptions: NAIRU (4.2%), inflation target (2.1%), neutral real rate (0.8%), term premium (1.2%), mortgage spread (1.7%), productivity plus working-age growth, housing supply drag (0.5 pp), and demographic growth (0.6% population).
- Bridge the model output toward the anchors linearly between quarters 9–20, then mean-revert beyond quarter 20 to avoid drift.
- Save anchor definitions and assumptions in `macro_anchor_assumptions.json` for auditability.

4. Long horizon (quarters 21–80)

- Apply scenario envelopes on top of the anchor path:
  - **Baseline**: the anchor-adjusted path.
  - **Mild Adverse**: +2.5 pp unemployment, −3.0 pp HPI growth, +1.0 pp mortgage rate, −1.5 pp GDP growth, +2.0 pp HY spread, with a small persistent HPI drag.
  - **Severe Adverse**: +5.5 pp unemployment, −7.0 pp HPI growth, +2.0 pp mortgage rate, −3.0 pp GDP growth, +4.0 pp HY spread, +1.5 pp delinquency, with deeper HPI drag.
  - **Demographic Low Growth**: permanent anchor shifts lowering population/workforce growth, GDP growth, and HPI growth.
- Each scenario blends triangular shocks (start, peak, end quarters) plus persistent anchor shifts to deliver plausible macro evolutions through year 20.

5. Final outputs

The “big CSV” `macro_forecast_paths.csv` lists every scenario–quarter–variable triple. The PD subset CSV/JSON provides a smaller set of key variables with unit and transformation metadata for ingestion.

5 How others use it

- Share the `outputs/` directory plus `macro_engine_schema.md`.
- Run `run_all.sh` (or the underlying scripts) inside the folder to regenerate the panel and forecasts.
- Drop the PD subset CSV into IFRS/Basel pipelines; the schema indicates which fields are YoY (%) versus levels.

6 What gets produced

- `outputs/macro_forecast_paths.csv`: the full 20-year forecast for every variable and scenario.
- `outputs/macro_forecast_short_horizon_intervals.csv`: near-term uncertainty bands (5/50/95 percentiles).
- `outputs/macro_model_diagnostics.json`: model settings and stability checks.
- `outputs/macro_anchor_assumptions.json`: long-run anchors used to guide the forecast.
- `outputs/macro_impulse_responses.csv`: impulse responses used for interpretation.
- `outputs/pd_macro_subset_sample.csv`: a small PD-ready file with key macro variables.
- `outputs/pd_macro_subset_sample.json`: units and transformations for the PD subset.
- `outputs/bvar_oos_backtest_table.csv`: out-of-sample BVAR forecast evaluation table (RMSE/MAE/coverage/DM).

7 New addition: BVAR out-of-sample backtest

To quantify short-horizon forecasting power, we added a dedicated rolling out-of-sample BVAR backtest script: `scripts/backtest_bvar_oos.py`.

Backtest design

- Rolling-origin pseudo out-of-sample evaluation on the quarterly model panel.
- Forecast horizons: 1 to 8 quarters.
- Default benchmark comparison: random walk (last observation carried forward).
- Two variable modes:
  - `benchmark` (12 variables, fast).
  - `full` (28 variables, slower).
- Optional simulation-based 90% interval coverage using predictive draws.

Metrics in the table

For each variable and horizon, the backtest table reports:

- `rmse_bvar`: root mean squared error of BVAR forecasts.
- `mae_bvar`: mean absolute error of BVAR forecasts.
- `coverage_90_bvar`: empirical coverage of the BVAR 90% interval.
- `rmse_rw`: RMSE of random-walk benchmark forecasts.
- `dm_stat_bvar_minus_rw_mse`: Diebold-Mariano-style test statistic using squared-error loss differential.
- `dm_pvalue_two_sided`: two-sided p-value for whether BVAR and random walk have equal predictive loss.

How it was executed in this session

The backtest was run and verified, with output written to: `outputs/bvar_oos_backtest_table.csv`. The latest verified run used the benchmark variable set with short runtime settings (`--max-origins 8 --origin-stride 2 --interval-sims 10`), producing an 8-origin, 12-variable, 8-horizon table.

8 Execution

Run the entire pipeline from the top folder:

```
./run_all.sh
```

This script does three things:

1. Fetches and rebuilds the quarterly data panel.
2. Runs the forecast engine with the configured scenarios.
3. Exports the PD-ready subset and metadata.

9 Interpretation of Outputs

- **Baseline** is the "most likely" path assuming no major shock.
- **Mild Adverse** is a moderate recession-style shock.
- **Severe Adverse** is a deep recession with higher unemployment and weaker housing.
- **Demographic Low Growth** lowers long-run growth assumptions to reflect structural drag.

Each row in `macro_forecast_paths.csv` corresponds to one future quarter for one scenario, containing values for each macro variable (e.g., unemployment, inflation, house-price growth).

10 How to share this with a PD team

1. Share the full folder, or at minimum `outputs/`.
2. Point them to `pd_macro_subset_sample.csv` and its JSON metadata.
3. If they need the full set of variables, use `macro_forecast_paths.csv`.

11 Known Limitations

- This package forecasts macro variables only; it does not build or calibrate PD models.
- Long-run outcomes are anchored on explicit assumptions; these can be edited in `macro_engine_config.json`.
- Data is pulled from public sources (FRED); revisions can change results slightly over time.
- Scenario start timing in V1 is one quarter late versus configured start quarter (known issue planned for next patch).
- Backtest evidence in V1 is limited and should be treated as directional, not conclusive, until larger out-of-sample runs are enforced in pipeline.