Northstar Analytics

CECL Model Suite
Methodology & Model Development Report

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Document Control

Version	Date	Author	Reviewer	Summary of Changes
4.0	2025-08-30	M. Chen	R. Patel	Initial client release for CECL Suite v4.0
4.1	2025-11-15	M. Chen	R. Patel	Expanded macro-scenario integration; added revolving EAD module
4.2	2026-02-17	M. Chen	R. Patel	Refined segmentation stability process; added calibration diagnostics; updated appendices

Distribution

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Disclaimer

Northstar Analytics provides the CECL Suite as a decision-support tool. The client is responsible for evaluating model appropriateness, implementing effective controls, and ensuring compliance with applicable accounting guidance and internal policies. Results are sensitive to data quality, segmentation, scenario selection, and management overlays.

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1. Overview

Purpose. This report describes the design and development of the Northstar CECL Suite v4.2, a modular expected credit loss (ECL) modeling framework intended to support Current Expected Credit Loss (CECL) allowance estimation for retail and small-business loan portfolios. The report is written in a vendor technical style and summarizes model methodology, development decisions, testing, and known limitations.

Scope. The CECL Suite supports amortizing and revolving products with monthly projections to contractual maturity (or behavioral maturity where applicable). The framework is designed to be configurable by product, segment, and portfolio-specific policy choices (e.g., reversion horizon, scenario weighting).

1.1 Deliverables and Model Outputs

- Primary output: Lifetime expected credit loss (ECL) at instrument level and aggregated by portfolio/segment.
- Supporting outputs: 12-month PD, lifetime PD term structure, LGD term structure, EAD/CCF projections, prepayment curves, discount factors.
- Audit artifacts: data lineage logs, model run metadata, scenario set identifiers, and reproducible configuration snapshots.

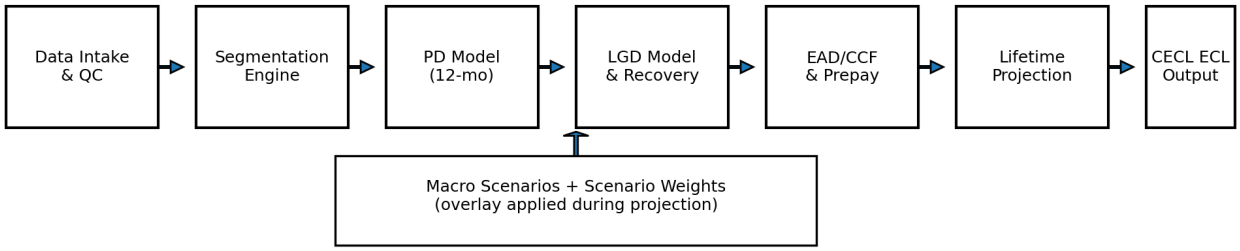
1.2 Intended Use and Non-Use

The CECL Suite is designed to support financial reporting and management insight for allowance estimation. It is not designed for real-time underwriting decisions, fraud detection, or loan-level pricing. Use outside allowance estimation should be assessed under the client model governance process.

1.3 Model Family and Components

The CECL Suite is a model family consisting of (i) segmentation, (ii) PD estimation, (iii) LGD and recovery estimation, (iv) EAD and utilization estimation (revolving products), (v) prepayment estimation, and (vi) a lifetime projection and discounting engine. The suite is designed to allow component substitution (e.g., roll-rate PD in place of logistic PD) where portfolio characteristics warrant.

Exhibit 1: Architecture Overview



2. Conceptual Framework

CECL measurement objective. CECL requires recognition of expected credit losses over the contractual term of financial assets, considering historical experience, current conditions, and reasonable and supportable forecasts. The CECL Suite operationalizes this objective via a monthly cash-flow projection approach that combines default and prepayment dynamics with exposure and recovery expectations.

2.1 Core Mechanics (Monthly Projection)

For each instrument i and projection month t, the expected credit loss contribution is computed as:

ECL_i = sum_t [DF_t * EAD_i,t * PD_i,t * LGD_i,t]

where DF_t is the discount factor based on the asset's effective interest rate (EIR) or an approved proxy, EAD_i,t is projected exposure, PD_i,t is marginal default probability, and LGD_i,t is loss severity conditional on default.

2.2 Reasonable and Supportable Forecasts

The framework distinguishes between: (i) a reasonable and supportable forecast period where macroeconomic variables influence PD, LGD, and (for revolving) utilization; and (ii) a reversion period where forecasts transition to long-run average assumptions. Client-configurable parameters include forecast horizon length, reversion method (linear or step), and long-run anchors.

2.3 Management Adjustments (Overlays)

The CECL Suite includes optional overlay mechanisms that apply multiplicative or additive adjustments to PD and/or LGD term structures. Overlays are not automatically recommended by the system; rather, they are applied based on documented management judgment and are tracked as separate run metadata to support governance and monitoring.

2.4 Conceptual Alternatives Considered

Approach	Description	Rationale / Considerations
Vintage loss-rate method	Summary method family used in industry practice.	Useful for stable portfolios; limited in capturing rapid shifts and term structure for longer-dated assets.
Roll-rate / transition matrix approach	Summary method family used in industry practice.	Interpretable; strong fit for delinquency-driven portfolios; requires stable delinquency reporting.
PD/LGD/EAD cash-flow	Summary method family	Provides modularity and

approach (selected)	used in industry practice.	term structure; supports macro integration and component diagnostics.

3. Model Architecture

The CECL Suite is implemented as a parameter-driven engine. Model configuration is stored as a versioned set of tables (segments, variable definitions, scenario sets, and run controls). The engine executes in a deterministic manner given identical inputs and configuration.

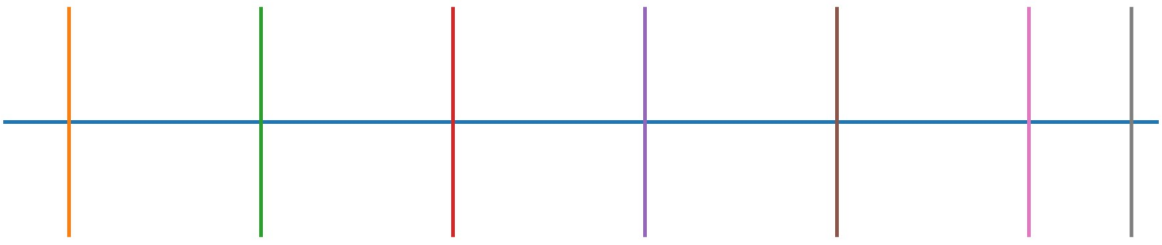
3.1 Component Interfaces

Each component consumes standardized intermediate tables and produces standardized outputs. This design enables substitution of components without rewriting downstream processing. For example, a roll-rate PD module can feed the lifetime projection engine in place of a logistic PD module.

3.2 Key Configuration Parameters (Examples)

Parameter	Notes
Forecast horizon	12 to 24 months typical; configurable by portfolio; controls macro influence window.
Reversion method	Linear transition to long-run mean; optional step reversion.
Scenario weighting	User-defined weights across baseline/adverse/severe scenarios (sum to 1.0).
Behavioral maturity (revolving)	Optional cap on projection term; based on historical account survival.
Prepayment treatment	Explicit prepayment curve vs implicit runoff via amortization; product-dependent.

3.3 Projection Timeline



Observation windows used for estimation and calibration are portfolio-specific, but a typical configuration uses 7 to 10 years of history including at least one stress period where available. The suite retains full lineage of observation windows used for each run.

4. Portfolio Segmentation

Segmentation is a primary driver of model accuracy and interpretability. The CECL Suite supports hierarchical segmentation where a portfolio is split into segments with materially different risk dynamics and loss behavior. Segmentation can be customer-based, loan-based, or both, depending on product.

4.1 Candidate Segmentation Variables

- Product type (e.g., auto, credit card, HELOC)
- Risk grade / internal rating
- Collateral type and lien position (secured products)
- Origination channel (branch, digital, indirect)
- Vintage / origination year band
- Geography (state / MSA)
- FICO / bureau score bands
- Utilization bands (revolving)

4.2 Segmentation Method (Hybrid Statistical + Business)

Northstar uses a hybrid approach: (i) exploratory analysis of loss and default heterogeneity across candidate splits; (ii) tree-based segmentation candidates (e.g., CHAID or CART) constrained by minimum segment size; and (iii) business review for operational interpretability and stability.

4.3 Segment Stability Assessment

Segment stability is evaluated using a three-part scorecard: (a) population stability (PSI) for key drivers; (b) loss rate stability across time; and (c) segment migration rates where grades/tiers change. Segments failing stability thresholds are reviewed for consolidation or redefinition.

Metric	Definition	Typical Threshold	Action if Breached
PSI (key driver)	Population shift vs. baseline period	< 0.10 (stable); 0.10-0.25 (watch); >0.25 (material)	Investigate driver mapping; consider re-segmentation
Loss-rate drift	12-mo net loss rate change YoY	> 25% relative change	Review macro layer and/or segment definition
Migration rate	Annual % moving between grades/tiers	> 30% moved	Assess rating governance; treat grades as time-varying covariates

5. Probability of Default (PD) Methodology

The CECL Suite supports multiple PD approaches. The default configuration uses a 12-month PD model estimated at the account level, then converted to a lifetime term structure via survival-style conversion and monthly hazard shaping. For delinquency-driven products, a roll-rate alternative is supported.

5.1 Default Definition and Event Window

Default is defined as a charge-off event or a sustained delinquency state consistent with client policy (e.g., 90+ DPD with no curing). The estimation target is a 12-month default indicator using forward-looking observation windows. Event definitions are configurable and version-controlled within the CECL Suite.

5.2 Logistic PD (Primary)

The logistic PD model estimates the probability of default within 12 months as a function of borrower, loan, and macroeconomic covariates. Variables are selected using a combination of univariate screening, correlation pruning, and stepwise selection with business constraints.

$$\text{logit}(PD_{12m}) = \beta_0 + \Sigma_k \beta_k * X_k + \Sigma_j \gamma_j * Macro_j$$

5.3 Variable Handling and Transformations

Continuous variables are winsorized at portfolio-specific percentiles (typically 1st/99th) and transformed using log or spline forms where appropriate. Missing values are handled via: (i) explicit missing indicators for informative missingness; and (ii) imputation to segment medians when missingness is operational.

5.4 Regularization and Overfitting Controls

To reduce overfitting risk, Northstar applies out-of-time validation and considers L2 (ridge) regularization when the candidate feature set is large. Coefficient stability and sign consistency are required unless an exception is documented.

5.5 Roll-Rate PD (Optional Alternative)

For portfolios with consistent delinquency reporting and sufficient delinquency history, PD can be estimated via transition matrices across delinquency states. The roll-rate approach is interpretable and can be robust in low-default environments when combined with smoothing and macro adjustments.

5.6 Illustrative Development Diagnostics (Example)

Segment	Obs (Acct-Months)	Default Rate (12m)	AUC (OOT)	KS (OOT)
Auto - Prime	1,240,000	0.85%	0.74	0.35

Auto - Near Prime	680,000	2.10%	0.71	0.31
Credit Card - Prime	2,050,000	1.60%	0.77	0.38
Credit Card - Subprime	510,000	6.80%	0.73	0.34
HELOC	430,000	0.65%	0.70	0.29

6. Loss Given Default (LGD) and Recovery Modeling

LGD is estimated as the discounted severity conditional on default, incorporating recoveries, collateral, workout timelines, and costs. The CECL Suite supports both (i) direct severity modeling and (ii) recovery-curve modeling over time.

6.1 LGD Definition

LGD is defined as (Charge-off Amount - Present Value of Recoveries) / EAD at Default. Recoveries may include cash recoveries, collateral liquidation proceeds, and third-party reimbursements, net of direct collection costs where available.

6.2 Recovery Curve Approach (Secured Products)

For secured products, recoveries are modeled as a curve over months since default. The curve shape is segment-specific and may depend on collateral type, lien position, and LTV. This approach supports explicit timing of recoveries within the discounting framework.

6.3 Direct Severity Approach (Unsecured Products)

For unsecured products (e.g., credit cards), LGD is modeled directly using beta regression or bounded linear models. Key drivers include utilization at default, customer score bands, and macro conditions that influence recovery effectiveness.

6.4 LGD Diagnostics (Example)

Segment	Mean LGD	P10 / P90	Notes
Auto - Prime	42%	28% / 58%	Collateral mitigates severity; stable recovery curves
Auto - Near Prime	54%	39% / 70%	Higher repossession costs; longer liquidation timelines
Credit Card - Prime	86%	80% / 93%	Unsecured; recoveries primarily via collections
Credit Card - Subprime	92%	87% / 97%	Lower recovery yields; sensitive to unemployment
HELOC	35%	18% / 55%	Highly dependent on lien position and property values

7. Exposure at Default (EAD), Utilization, and Prepayment

EAD modeling differs by product. For amortizing products, EAD is primarily driven by contractual amortization and prepayment. For revolving products, EAD includes projected utilization driven by credit line dynamics and customer behavior.

7.1 Amortizing Products

For amortizing products, the engine projects scheduled balance using contractual terms and applies prepayment curves by segment. Partial prepayments are modeled as a monthly single-month mortality (SMM) rate derived from historical data.

7.2 Revolving Products (CCF / Utilization)

For revolving products, EAD is modeled as: EAD_t = Balance_t + CCF_t * (Line_t - Balance_t), where CCF_t (credit conversion factor) captures expected drawdown on unused lines prior to default. CCFs are estimated by segment and may incorporate macro covariates.

7.3 Prepayment / Attrition

Prepayment is modeled using either (i) cohort-based curves (CPR/SMM) or (ii) a simplified attrition hazard. Prepayment affects both exposure projection and the contractual term over which losses are recognized.

7.4 Illustrative Prepayment Curves (Example)

Segment	SMM (Year 1)	SMM (Year 2)	SMM (Year 3+)	Comments
Auto - Prime	1.8%	1.4%	1.0%	High refinance activity early, tapering thereafter
Auto - Near Prime	1.2%	1.0%	0.8%	Lower refinance sensitivity
HELOC	0.9%	0.8%	0.7%	Behavior driven; sensitive to rate environment
Credit Card - Prime	2.5%	2.0%	1.8%	Attrition proxy; captures account closure

8. Lifetime Projection Engine and Discounting

The lifetime projection engine combines component term structures (PD, LGD, EAD, prepayment) on a monthly grid to estimate lifetime ECL. The engine is deterministic and uses a transparent set of calculations designed for auditability.

8.1 Monthly Hazard and Term Structure

When starting from a 12-month PD, the suite converts to a monthly hazard rate using a parametric hazard shape calibrated to observed default timing. For products where defaults are front-loaded (e.g., unsecured), the hazard curve is steeper in early months. For secured longer-term products, the curve is flatter and more sensitive to macro conditions.

8.2 Discounting Approach

Discounting is performed using the effective interest rate (EIR) at origination where available. If EIR is not available, a product-level proxy rate may be used with client approval. The suite tracks the discounting method and rate source used for each run.

8.3 Treatment of Recoveries

When recovery curves are used, recoveries are recognized as negative loss cash flows in the projection timeline and discounted accordingly. For direct severity models, recovery timing is implicitly embedded in the LGD estimate. Clients may elect to apply a conservative lag assumption for recoveries when data is limited.

9. Macroeconomic Scenarios and Forecast Integration

Macroeconomic variables influence PD (and in some cases LGD and utilization) through estimated relationships and scenario paths. The suite supports multiple scenarios (e.g., baseline, adverse, severe) and user-defined weights.

9.1 Macro Variables

Variable	Typical Use
Unemployment rate	Primary driver for unsecured defaults; also affects recoveries
GDP growth	Broad economic activity; used as a secondary driver
House price index (HPI)	Key for HELOC and mortgage-related severity
Used vehicle price index	Key for auto collateral values
Interest rate level	Affects prepayment and revolving utilization dynamics

9.2 Scenario Weighting

Scenario weights are not prescribed by the model and are expected to be governed by the client. The suite supports storing scenario sets and weights as named objects (e.g., '2026Q1_ForecastSet_A') to ensure reproducibility and monitoring.

9.3 Reversion to Long-Run

After the reasonable and supportable horizon, macro variables (or their modeled impacts) revert to long-run values. Long-run anchors may be (i) historical averages over a client-selected period, (ii) vendor-provided long-run assumptions, or (iii) policy-based anchors. The reversion method is configurable.

10. Calibration, Benchmarking, and Development Testing

Calibration aligns modeled losses with observed experience under a chosen calibration window. Benchmarking compares model outputs to simpler reference approaches and to key portfolio indicators.

10.1 Calibration Approach

Calibration is performed at the segment level using either (i) a multiplicative scaler on PD and/or LGD term structures, or (ii) an additive adjustment to hazard rates, depending on segment characteristics. Calibration targets are typically net charge-off rates and/or realized lifetime loss rates for closed cohorts.

10.2 Challenger Benchmarks

Typical challengers include: (a) trailing 12-quarter average net loss rate; (b) vintage loss curves; (c) roll-rate matrices with smoothing; and (d) simplified PD-only approaches with constant LGD. Discrepancies are investigated and documented during development.

10.3 Back-Test Summary (Illustrative)

Portfolio	Back-test Window	Modeled Loss Rate	Realized Loss Rate	Commentary
Auto	2023Q1-2024Q4	1.92%	2.05%	Close fit; mild underprediction during late-2024
Credit Card	2023Q1-2024Q4	4.85%	4.60%	Slight overprediction; macro sensitivity conservative
HELOC	2022Q1-2024Q4	0.72%	0.78%	Stable; HPI path drives severity

10.4 Sensitivity Testing (Examples)

- Unemployment +100 bps shock over forecast horizon; assess incremental ECL and segment drivers.
- HPI -10% shock for collateral-dependent segments; assess LGD impact and recovery timing.
- Scenario weight shift (baseline 50% -> 30%); observe ECL change and contribution by scenario.
- Prepayment -20% relative change; evaluate term extension effects on lifetime ECL.

11. Key Assumptions, Limitations, and Appropriate Use

11.1 Key Assumptions (Non-Exhaustive)

- Account performance history is representative of future behavior after considering macro forecasts and current conditions.
- Default definitions and charge-off timing are consistent over the estimation and application periods.
- Macroeconomic scenario paths are internally consistent and reflect reasonable and supportable expectations for the portfolio.
- Data inputs (balances, delinquency, recoveries, collateral values) are accurate and reconciled to source systems.
- Prepayment and utilization dynamics are stable within segments, subject to macro adjustments where enabled.

11.2 Limitations

- Low-default segments may require additional smoothing, pooling, or expert judgment overlays.
- Structural breaks (changes in underwriting, servicing, or portfolio composition) can degrade model performance.
- Collateral value indices are proxies and may not fully capture local market behavior for specific assets.
- Recovery timing assumptions may be uncertain when recoveries are not tracked at sufficient granularity.
- Scenario weights and overlay choices can materially change results; these are governed outside the model.

11.3 Appropriate Use and Governance Expectations

Northstar expects clients to implement governance controls around (i) configuration changes, (ii) scenario selection and weights, (iii) overlays, and (iv) periodic monitoring. Users should retain run artifacts and support reproducibility for audit and validation. Material deviations from documented methodology should be evaluated under the client's model change policy.

12. Appendices

Appendix A: Glossary

Term	Definition
AUC	Area Under the ROC Curve; classification discrimination measure.
CCF	Credit Conversion Factor; expected conversion of unused line to exposure prior to default.
DF	Discount Factor; present value multiplier based on effective interest rate.
EAD	Exposure at Default; projected exposure conditional on default.
ECL	Expected Credit Loss; present value of expected losses over contractual term.
LGD	Loss Given Default; severity conditional on default.
PD	Probability of Default; likelihood of default over a horizon.
PSI	Population Stability Index; measure of distribution shift.
SMM/CPR	Single Monthly Mortality / Conditional Prepayment Rate; prepayment measures.

Appendix B: Example Variable Catalog (Excerpt)

The following excerpt illustrates common variable definitions used in the CECL Suite. The full catalog is maintained as a versioned artifact in the implementation environment.

Variable	Type	Definition	Notes
fico_band	Categorical	Borrower credit score band at observation month	Derived from bureau; missing -> 'Unknown'
utilization	Continuous	Balance / Credit Line (revolving)	Winsorized at 1st/99th percentile
dpd_bucket	Categorical	Days past due bucket	Used for roll-rate

		(0, 1-29, 30-59, 60-89, 90+)	option
hpi_yoy	Continuous	YoY % change in house price index	Scenario-driven during forecast horizon
unemp_rate	Continuous	Unemployment rate level	Scenario-driven; affects unsecured PD

Appendix C: Example Calculation Walkthrough (Simplified)

1. Given: EAD_t = $10,000, PD_t (marginal) = 0.30%, LGD_t = 60%, DF_t = 0.997 (monthly).
2. Monthly expected loss contribution = DF_t * EAD_t * PD_t * LGD_t = 0.997 * 10,000 * 0.0030 * 0.60 ≈ $17.95.
3. Lifetime ECL is the sum of monthly contributions over the projection horizon, net of discounted recoveries where modeled explicitly.

Appendix D: Illustrative Output Fields (Excerpt)

Field	Description	Example
run_id	Unique model run identifier	2026Q1_SRBank_00047
scenario_set	Named scenario collection	2026Q1_ForecastSet_A
segment_id	Segment code used by engine	CC_PRIME
ecl_lifetime	Lifetime expected credit loss (present value)	125.42
pd_12m	12-month PD at run date	0.016
lgd_mean	Mean LGD for segment	0.86