An extendable, integrated, and dynamic approach to forecasting and stress-testing credit risk

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Abstract

An integrated and extendable approach for stress-testing loan portfolios is presented, comprising of both a loan production and a credit risk component. In this approach, we simulate a completed portfolio using realistic loan parameters and distributional assumptions. Thereafter, the uncertain cash flow history (or receipts) of these loans are generated within a multistate framework. A simulation-based approach is ideal for stress-testing since it allows for evaluating a range of conditions. From these completed loans, we compute various portfolio credit risk metrics, e.g., default and loss rates. Stress scenarios are introduced by varying the loan parameters accordingly, thereby resulting in a range of portfolios. A classical approach does not typically integrate loan production, nor does it embed the correlation structure amongst risk metrics. We therefore integrate the forecasting of risk metrics with receipt-generation itself. Given data, the loan parameters within our extendable approach can be dynamically modelled as functions of input variables using any technique. Overall, our approach can render predictions that are more dynamic and realistic, which can enhance stress-testing practices within any bank.

A novel stress-testing framework

We present a novel stress-testing framework that consists of a loan production and a credit risk component, as depicted in Fig. 1. A loan portfolio and its associated credit risk are simulated according to these high-level steps:

1. The loan production component simulates the loan volume for a given month along with loan-level attributes for each new loan.
2. The credit risk of the loans originating in that month are then inferred by first forecasting each loan's cashflow/receipt over its lifetime.
3. The associated loan balance and delinquency for each period in the loan's life are then calculated and the portfolio credit risk for the specific origination cohort is calculated.
4. The three above steps are repeated for over a range of periods given time-dependent parameters.

A stress-testing framework

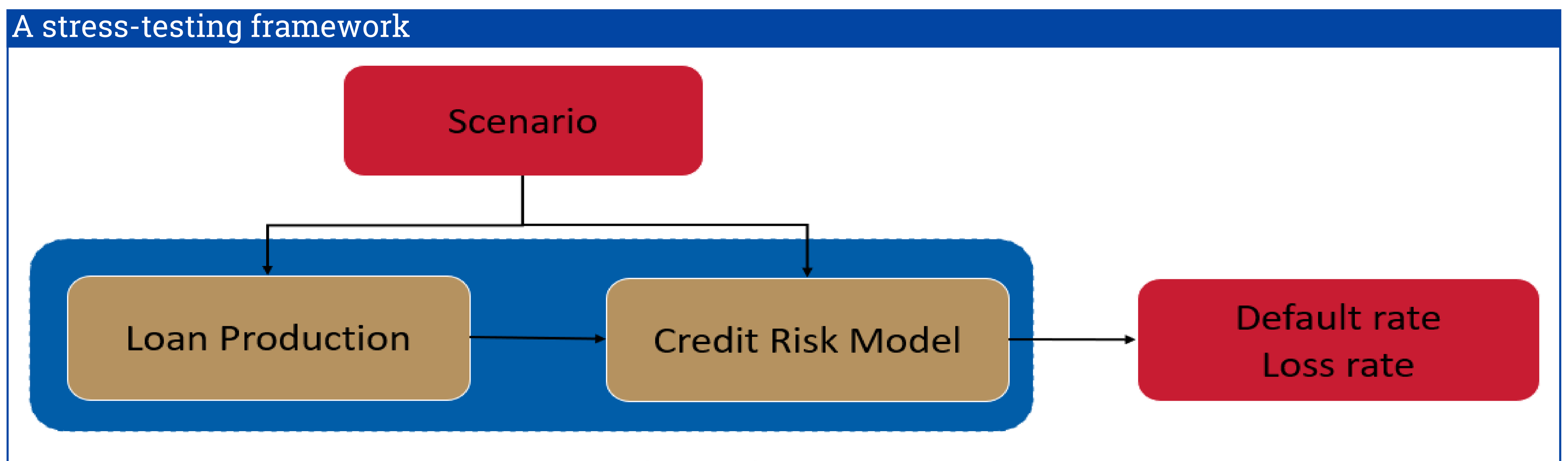

Figure 1: A framework for stressing a credit portfolio.

Within the loan production component, various loan attributes are generated as follows:

1. New monthly loan volumes: truncated Normal distribution;
2. Principal amount: truncated Beta distribution;
3. Annual interest rates: truncated Beta distribution; and
4. Contractual terms: truncated Normal distribution.

Loan production metrics

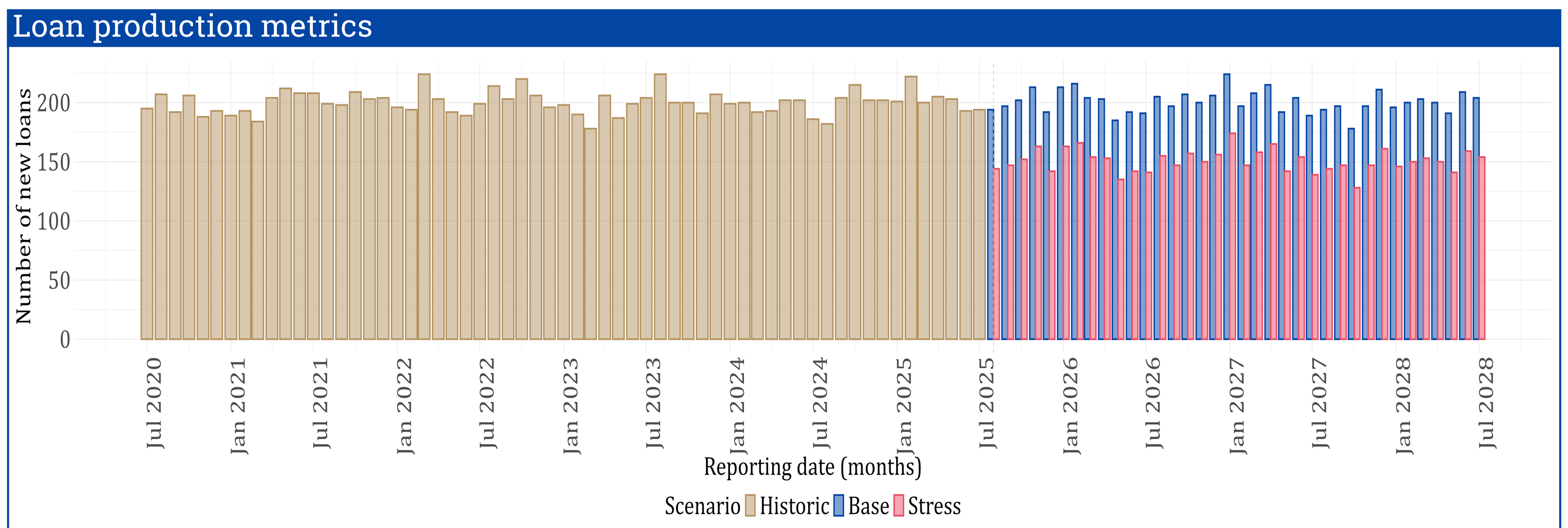

Figure 2: Simulated loan volumes over an artificial historic and forecast period, where loan origination is both kept constant (base scenario) and stressed (stress scenario).

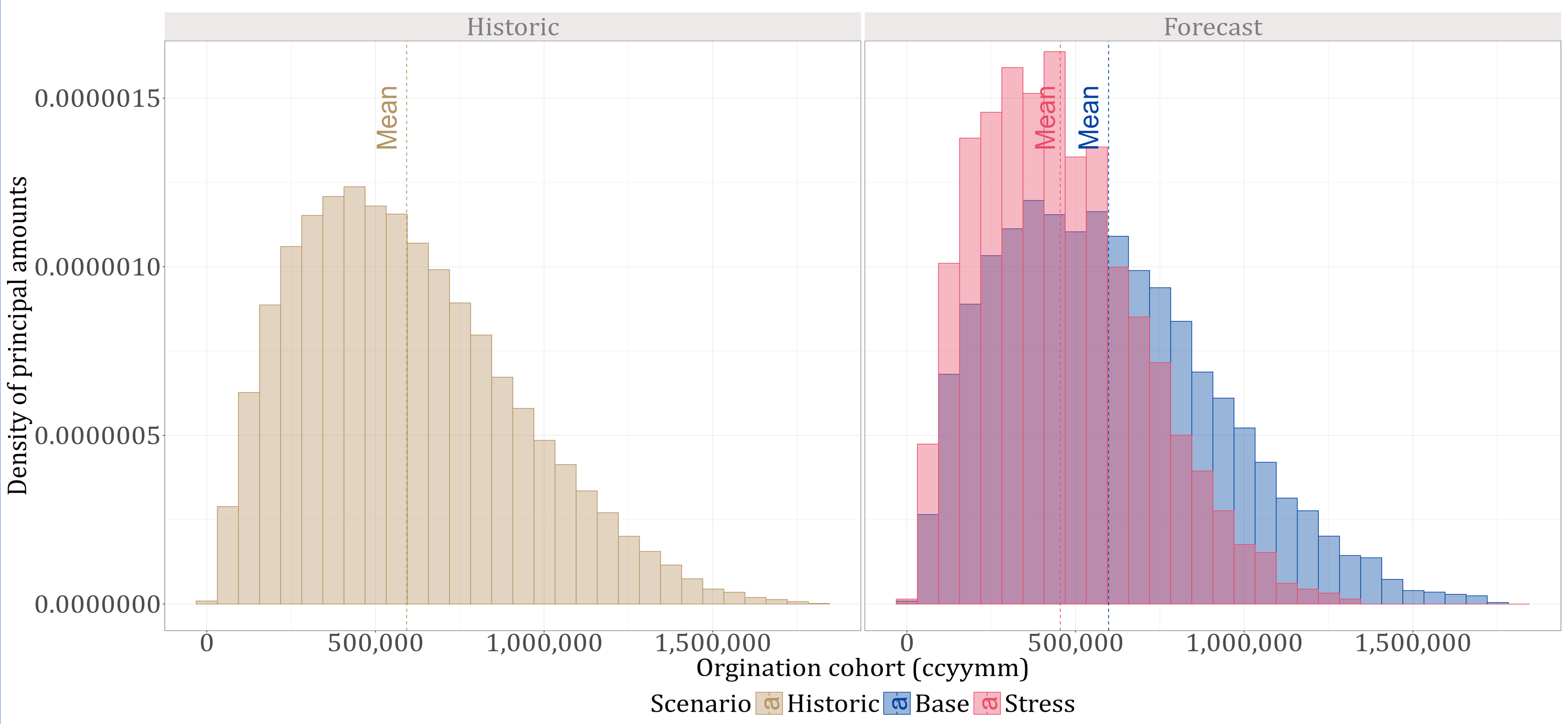

Figure 3: Simulated loan principal amounts over an artificial historic and forecast period, where principal amounts are both kept constant (Base scenario) and reduced (stress scenario).

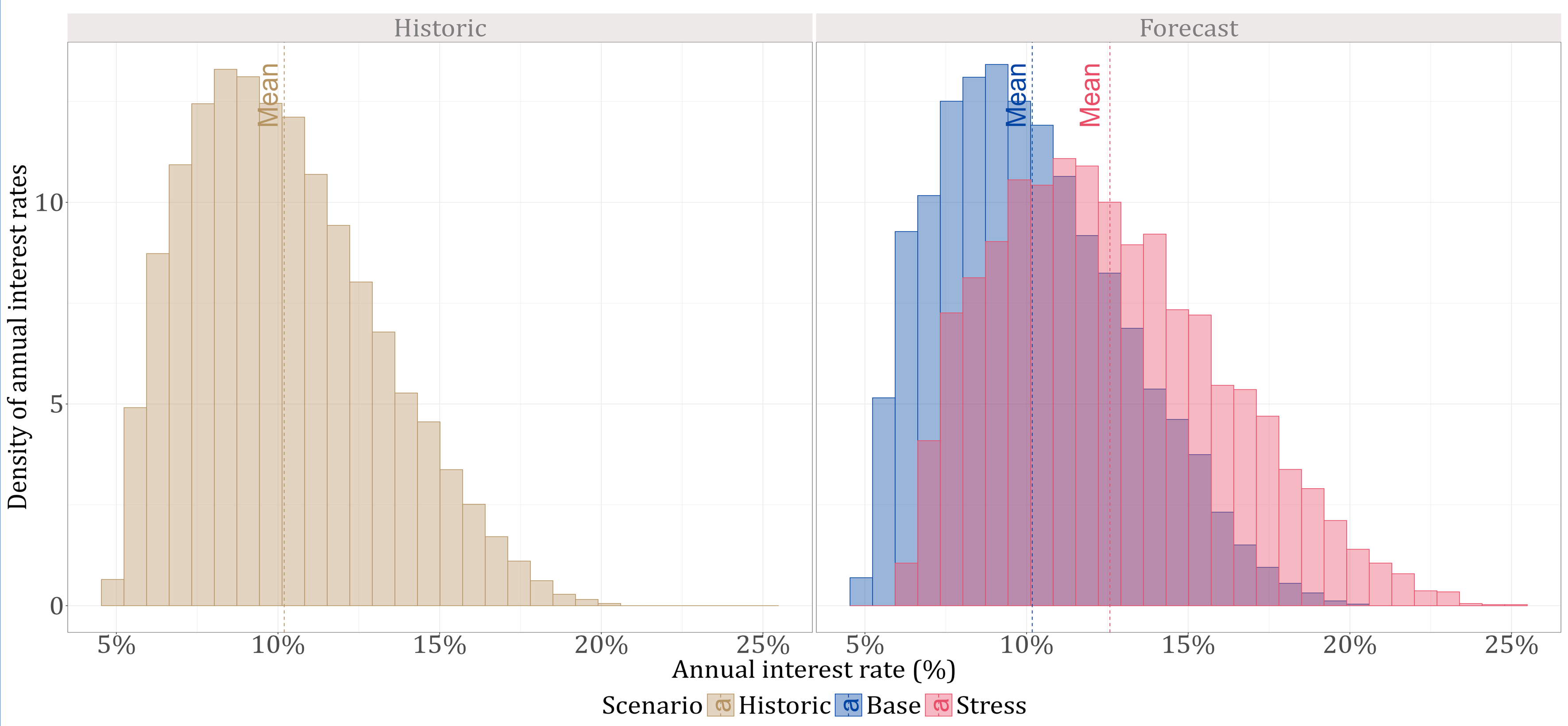

Figure 4: Simulated annual interest rates charged to loans over an artificial historic forecast period, where annual interest rates are both kept constant (base scenario) and increased (stress scenario).

Forecasting the cashflows/receipts $R_t \geq 0$ of each simulated loan proceeds with a two-pronged approach. Firstly, a one-step transition matrix forecasts the next ***account state*** of a loan at time t X_t, given its current state X_{t-1}. A loan is permitted to transition between the *payment* (P) and *delinquency* (D) states, before ultimately transitioning into either the *settlement* (S) or *write-off* (W) (where both are absorbing states). See Table 1 for all possible transitions between account states.

Table 1: A conceptual transition matrix showing possible transitions amongst four account states that a typical loan can assume during its lifetime.

		To			
		Payment	Delinquency	Settlement	Write-off
From	Payment	p_{PP}	p_{PD}	p_{PS}	p_{PW}
	Delinquency	p_{DP}	p_{DD}	p_{DS}	p_{DW}
	Settlement	0	0	1	0
	Write-off	0	0	0	1

Secondly, the loan receipt forecasts are generated for the entire lifetime of the loan given the state forecast of the loan X_t. Let

1. I_t denote the expected installment of a loan at time t;
2. B_t denote the associated balance of the same loan at t;
3. r denote the annual interest charged to that loan;
4. $w \in [0, 1]$ be the write-off rate and t_w be the associated write-of point;
5. *Payment probability* (PP) $\mathbb{P}(R_t = I_t) = b^{(1)}$;
6. $b_t^{(2)}$ be the PP when moving from D → W;
7. C be the cure amount; and
8. W be the recovered amount using $b_t^{(2)}$ for the associated receipts.

Given account state X_t, the R_t is subsequently forecast using the suite of equations in Table 1. These receipts then inform the account balances and delinquency measurements over time, thereby enabling the portfolio-level default and loss rate to be calculated.

Table 1: The receipts of an account transitioning between different account states.

		To			
		Payment	Delinquency	Settlement	Write-off
From	Payment	I_t	0	$B_{t-1} \cdot (1 + r/12)$	W
	Delinquency	C	$\begin{cases} I_t & \text{if } b_t^{(1)} < u \\ 0 & \text{otherwise} \end{cases}$	$B_{t-1} \cdot (1 + r/12)$	$B_{t_w - 1} \cdot \left(1 + \frac{r}{12}\right) \cdot (1 - w)$

Loans are simulated over a long *historic* period, before an artificial forecast period is introduced. Parameters are kept constant within a *base* scenario, whereas they are perturbed within a *stress* scenario; itself summarised as:

1. Loan production: fewer monthly loans, smaller principal amounts, higher annual interest rates.
2. Receipt generation: higher transition rates $P \to D$, $P \to W$, $D \to D$, and $P \to W$, and lower PP $b_t^{(1)}$ and $b_t^{(2)}$.

Figs. 2 to 4 respectively depict the related loan-production distributions over the historic and forecast scenarios. The default-rate of the resulting portfolio is shown in Fig. 5, whereas the loss-rate and it's related metrics are shown within Figs. 6 to 8.

Credit risk metrics

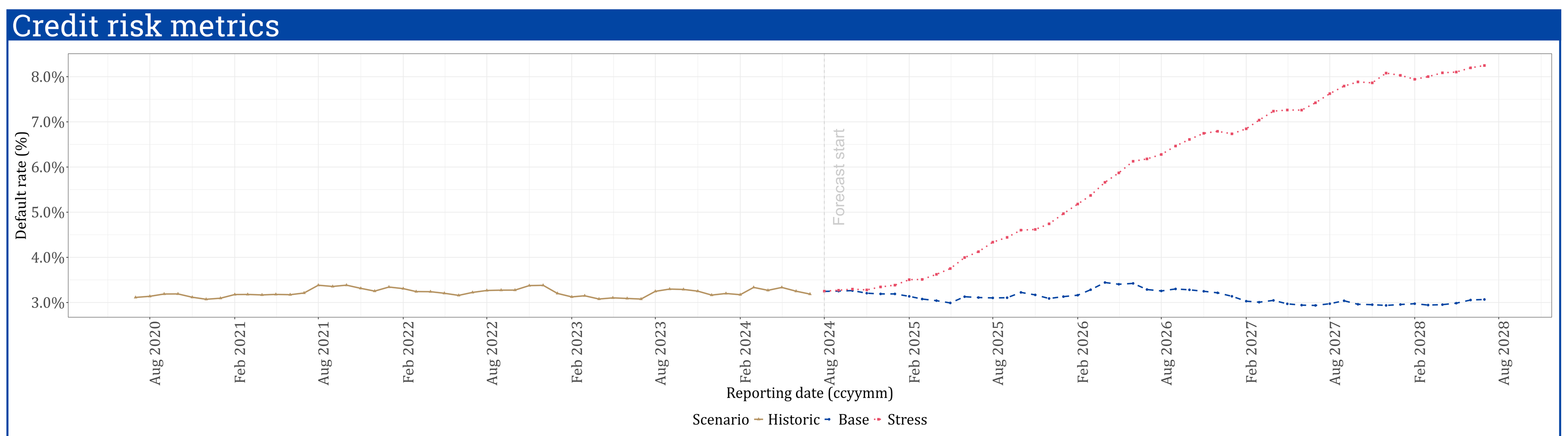

Figure 5: The 12-month default rate of a simulated credit portfolio shown over an artificial historic and forecast period, where the latter is split into a *base* and *stress* scenario.

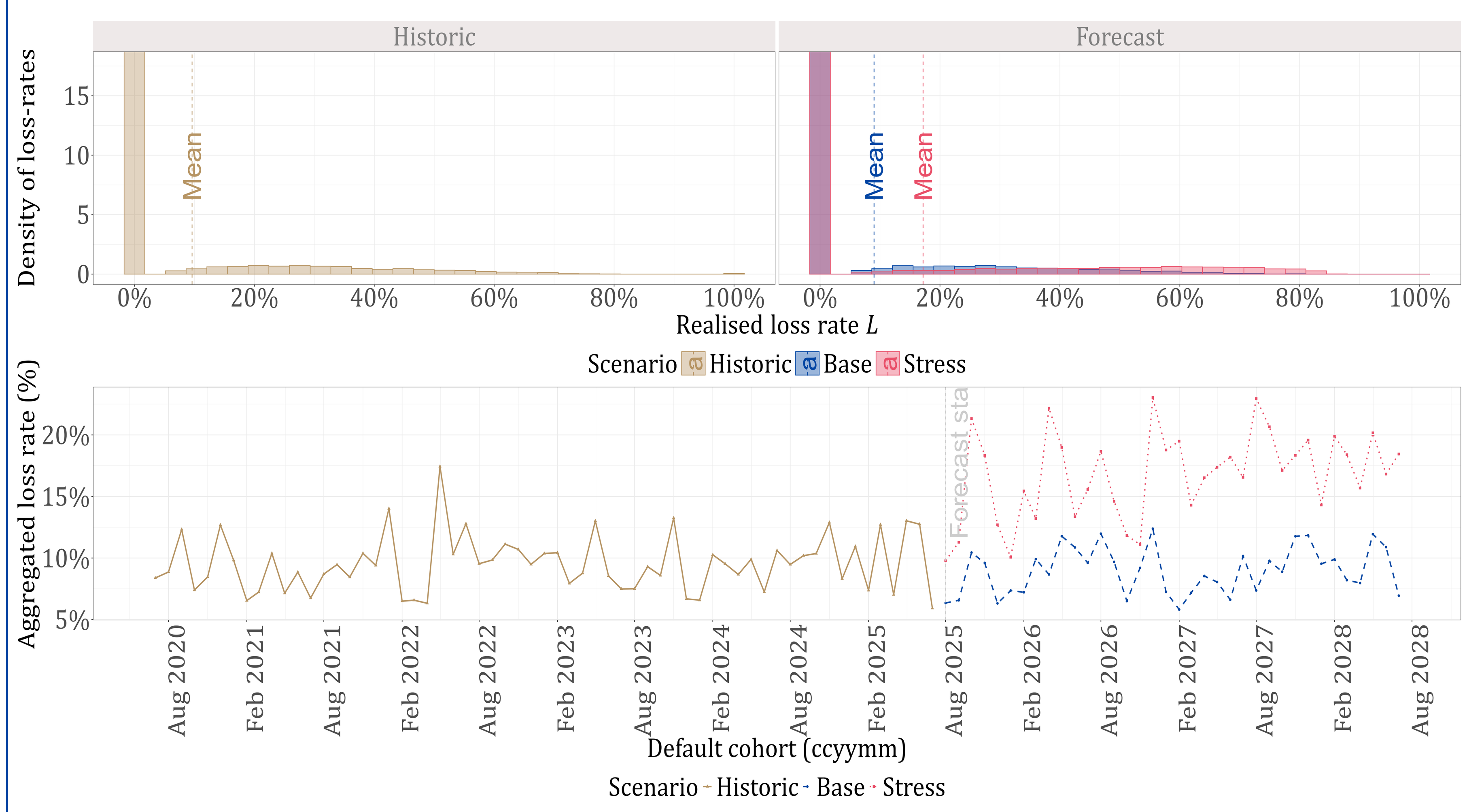

Figure 6: The aggregated loss rate of resolved defaults for a simulated credit portfolio shown for a *base* and *stress* scenario.

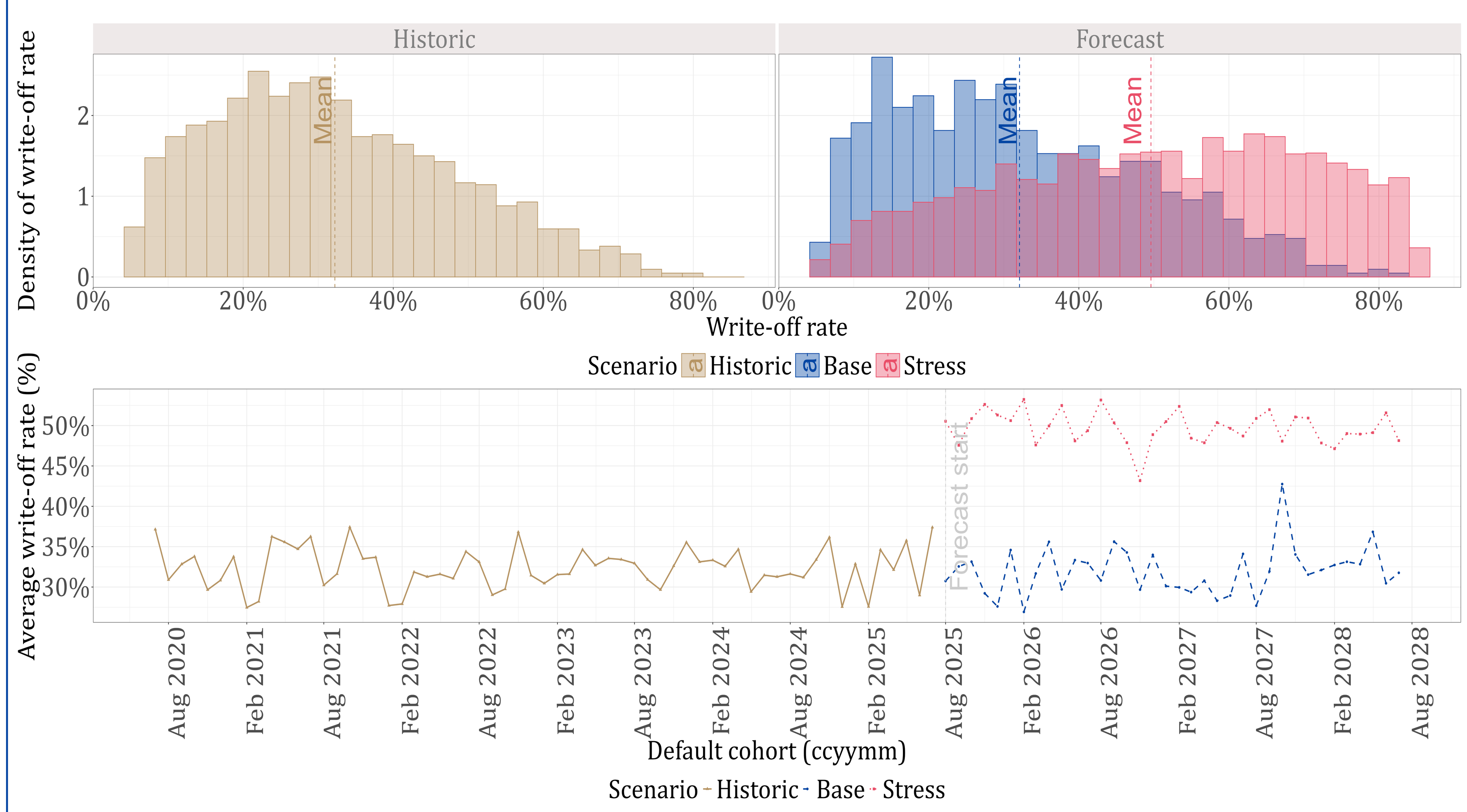

Figure 7: The write-off rate of a simulated credit portfolio shown over an artificial historic and forecast period, where the latter is split into a *base* and *stress* scenario.

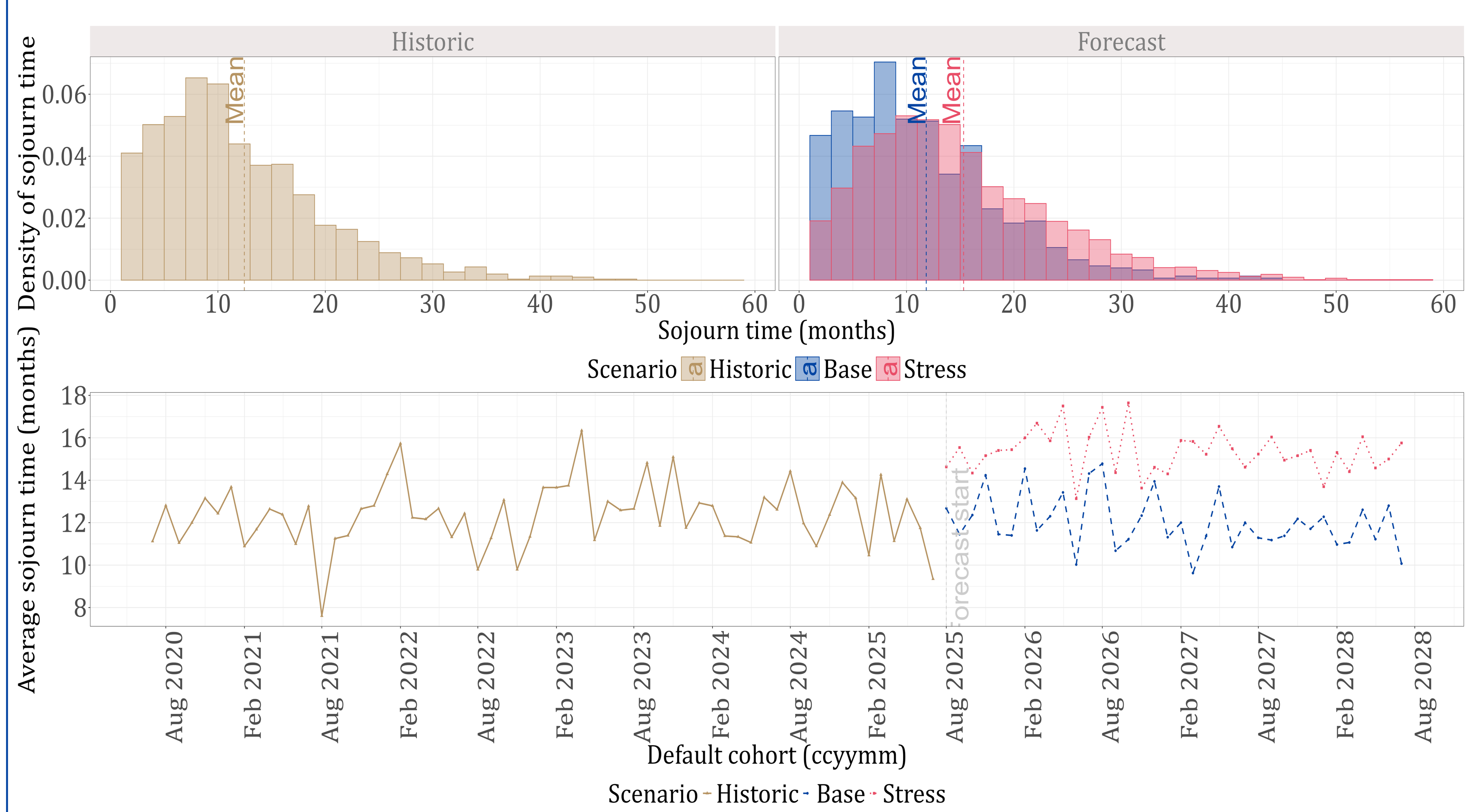

Figure 8: The sojourn-time of a simulated credit portfolio shown over an artificial historic and forecast period, where the latter is split into a *base* and *stress* scenario.