Technical Documentation: Detailed Sheet

Twyne stETH-ETH Boosted Looping Economics Model

Twyne Protocol

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Abstract

This document provides a comprehensive technical description of the "Detailed Sheet" in the Boosted Looping Economics spreadsheet. It describes all input parameters, calculated quantities, and the mathematical formulas governing the economics of leveraged stETH-ETH yield farming positions using the Twyne credit delegation protocol. This document is intended as a companion to the Twyne V1 Whitepaper and assumes familiarity with the concepts therein.

Contents

1 Introduction

The Detailed Sheet models the economics of a leveraged yield farming strategy where a user:

1. Deposits stETH as collateral on Aave
2. Borrows ETH against the stETH
3. Stakes the borrowed ETH via Lido to obtain more stETH
4. Repeats the loop to amplify exposure

Using Twyne's credit delegation mechanism (see Whitepaper Section 4), borrowers can exceed the standard Aave LTV limits by utilizing Credit LP (CLP) collateral, thereby achieving higher leverage than would otherwise be possible.

The sheet computes two primary outputs across a parameter grid:

- **Looped Net Farming Yield**: The annualized net yield for the leveraged position
- **Days to Liquidation**: Time until liquidation if the yield spread turns negative

2 Sheet Structure Overview

The Detailed Sheet is organized into the following major sections:

Table 1: Sheet Section Overview

Section	**Rows (approx.)**	**Purpose**
Borrower Inputs	11–18	Core market parameters
Safety Parameters	19–20	Liquidation buffer settings
Yield Matrix (HF-based)	10–31	Net yield by Health Factor & Boosted Liq. LTV
Days to Liquidation (HF-based)	10–31 (cols S–AD)	Liquidation timeline
CLP Inputs	34–38	Credit LP parameters
Yield Matrix (Leverage-based)	37–76	Net yield by Leverage & Boosted Liq. LTV
Interest Rate Model Params	40–45	Twyne IR model coefficients
Leverage Axes Configuration	50–52	Leverage range settings
Yield Improvement Matrix	80+	Percentage improvement vs baseline

3 Input Parameters

3.1 Borrower Parameters

These parameters define the borrower's market conditions:

Table 2: Borrower Input Parameters

Cell	**Symbol**	**Description**	**Example Value**
C11	$\tilde{\lambda}_e^C$	Liquidation LTV of borrower's collateral (C) on Aave	95%
C12	$\tilde{\lambda}_t^{\max}$	Twyne Maximum Boosted Liquidation LTV	98%
C13	r_{stake}	Lending + Staking Rate (stETH yield)	3.60%
C14	r_{borrow}	Aave ETH Borrow Rate	20.00%
C17	$\text{HF}^{\max}$	Maximum Health Factor (axis upper bound)	1.10
C18	$\text{HF}^{\min}$	Minimum Health Factor (axis lower bound)	1.00

3.2 CLP Parameters

These parameters govern the Credit LP economics:

Table 3: Credit LP Input Parameters

Cell	Symbol	Description	Example Value
C34	$\tilde{\lambda}_e^{\text{CLP}}$	Liquidation LTV of CLP collateral on Aave	95%
C35	$r_{\text{CLP,lend}}$	CLP lending rate on Aave	3.60%
C36	$1-\beta_{\text{safe}}$	Complement of Safety buffer	15%
C38	$IR(u)$	Twyne credit delegation interest rate	varies
C39	$r_{\text{CLP,total}}$	Total CLP rate: $r_{\text{CLP,lend}} + u \cdot IR(u)$	7.92%

3.3 Interest Rate Model Parameters

The Twyne interest rate model (see Whitepaper Section 5) uses:

Table 4: Interest Rate Model Parameters

Cell	Symbol	Description	Example Value
C42	$I_{\min}$	Minimum interest rate	0.00%
C43	I_0	Interest Rate at kink	0.80%
C44	u_0	Utilization at kink	90.00%
C45	$I_{\max}$	Maximum Interest Rate	20.00%
C46	γ	Curvature parameter	32.00

3.4 Axis Range Parameters

Table 5: Axis Configuration Parameters

Cell	Symbol	Description	Example Value
C50	$L^{\max}$	Maximum Leverage	50.00
C51	$L^{\min}$	Minimum Leverage	7.33

4 Derived Quantities

4.1 Boosted Liquidation LTV Grid

The column headers (G11:P11) represent a range of "Boosted Liquidation LTV" values, interpolated between the Aave LTV and the Twyne maximum:

$$\tilde{\lambda}_{t,i} = \tilde{\lambda}_e^C + \frac{i}{9} \cdot \left(\tilde{\lambda}_t^{\max} - \tilde{\lambda}_e^C \right), \quad i = 0, 1, \ldots, 9 \tag{1}$$

For example, with $\tilde{\lambda}_e^C = 0.95$ and $\tilde{\lambda}_t^{\max} = 0.98$:

$$\tilde{\lambda}_t \in \{0.950, 0.953, 0.957, 0.960, 0.963, 0.967, 0.970, 0.973, 0.977, 0.980\}$$

4.2 Health Factor Grid

The row indices (F12:F31) represent Health Factor values, interpolated as:

$$\mathrm{HF}_j = \mathrm{HF}^{\max} - \frac{j}{19} \cdot \left(\mathrm{HF}^{\max} - \mathrm{HF}^{\min}\right), \quad j = 0, 1, \ldots, 19 \tag{2}$$

This produces Health Factors from 1.10 down to 1.00 in 20 steps.

4.3 Leverage from LTV

Leverage is derived from LTV via the standard looping formula:

$$L = \frac{1}{1 - \lambda_t} \tag{3}$$

For example:

- $\lambda_t = 0.80 \Rightarrow L = 5\times$
- $\lambda_t = 0.95 \Rightarrow L = 20\times$
- $\lambda_t = 0.98 \Rightarrow L = 50\times$

4.4 Operating LTV from Health Factor

Given a Boosted Liquidation LTV ($\tilde{\lambda}_t$) and a Health Factor, the operating LTV is:

$$\lambda_t = \frac{\tilde{\lambda}_t}{\mathrm{HF}} \tag{4}$$

5 Core Formulas

5.1 Credit Delegation Cost Term

The spreadsheet calculates the cost a borrower pays for credit delegation. This appears as a term in the yield formula (e.g., cell G12) that multiplies the credit delegation interest rate ($IR(u)$, cell C38) by a factor representing the ratio of delegated credit to borrower collateral.

From the yield formula in cell G12:

```
C38 * ((G11/((1-C36)*C34)) - (C11/C34))
```

Cell C36 stores $(1 - \beta_{\text{safe}})$, so the term `(1-C36)` recovers β_{safe}. The CLP cost factor Ψ is therefore:

$$\Psi = \frac{\tilde{\lambda}_t}{\beta_{\text{safe}} \cdot \tilde{\lambda}_e^{\text{CLP}}} - \frac{\tilde{\lambda}_e^{C}}{\tilde{\lambda}_e^{\text{CLP}}}, \tag{5}$$

as expected from the credit delegation invariant int eh Whitepaper, where:

- $\tilde{\lambda}_t$ is the Boosted Liquidation LTV (column headers G11:P11)
- $\beta_{\text{safe}} = 1 - \texttt{C36}$ is Twyne's safety buffer parameter
- $\tilde{\lambda}_e^{\text{CLP}}$ is the liquidation LTV of the CLP collateral on Aave (cell C34)
- $\tilde{\lambda}_e^{C}$ is the liquidation LTV of the borrower's collateral (C) on Aave (cell C11)

Note on asset agnosticism: The spreadsheet is agnostic to which specific asset is used as CLP collateral. In the stETH-ETH looping scenario, the borrower's collateral (C) is stETH, while the CLP collateral could be stETH or ETH—all that matters is its liquidation LTV on the external lending market.

Relationship to Whitepaper Equation 7: This matches the whitepaper's credit reservation invariant exactly:

$$C_{LP}^{\text{ideal}} = C \cdot \left(\frac{\tilde{\lambda}_t}{\beta_{\text{safe}} \cdot \tilde{\lambda}_e^{\text{CLP}}} - \frac{\tilde{\lambda}_e^C}{\tilde{\lambda}_e^{\text{CLP}}} \right) \tag{6}$$

5.2 Looped Net Farming Yield (Health Factor Parameterization)

The primary yield calculation, parameterized by Health Factor and Boosted Liquidation LTV. Let Ψ denote the CLP cost factor from Equation (5), the yield formula is:

$$\boxed{Y = \frac{r_{\text{stake}} - r_{\text{borrow}} \cdot \lambda_t - IR(u) \cdot \Psi}{1 - \lambda_t}} \tag{7}$$

where $IR(u)$ is the Twyne interest rate (cell C38) from the interest rate model (Section 7).

Derivation:

Consider a looped position with n iterations. Let C_0 be the initial collateral. After looping:

$$\text{Total Collateral} = C_0 \cdot \sum_{k=0}^{n-1} \lambda_t^k = C_0 \cdot \frac{1}{1 - \lambda_t} \tag{8}$$

$$\text{Total Debt} = C_0 \cdot \sum_{k=1}^{n} \lambda_t^k = C_0 \cdot \frac{\lambda_t}{1 - \lambda_t} \tag{9}$$

The net yield on initial capital is:

$$Y = \frac{(\text{Collateral Yield}) - (\text{Borrow Cost}) - (\text{CLP Cost})}{\text{Initial Capital}} \tag{10}$$

$$= \frac{r_{\text{stake}} \cdot \frac{C_0}{1-\lambda_t} - r_{\text{borrow}} \cdot \frac{C_0 \cdot \lambda_t}{1-\lambda_t} - IR(u) \cdot \Psi \cdot \frac{C_0}{1-\lambda_t}}{C_0} \tag{11}$$

Simplifying yields Equation (7).

5.3 Looped Net Farming Yield (Leverage Parameterization)

An alternative formulation uses leverage L directly. Leverage and operating LTV are related by:

$$L = \frac{1}{1 - \lambda_t} \quad \Leftrightarrow \quad \lambda_t = \frac{L - 1}{L} \tag{12}$$

Substituting into Equation (7):

$$Y = \frac{r_{\text{stake}} - r_{\text{borrow}} \cdot \dfrac{L-1}{L} - IR(u) \cdot \Psi}{1/L} \tag{13}$$

which simplifies to:

$$Y = L \cdot r_{\text{stake}} - (L - 1) \cdot r_{\text{borrow}} - L \cdot IR(u) \cdot \Psi \tag{14}$$

The sheet includes a validity check: if the target leverage exceeds the maximum achievable leverage at a given Boosted Liquidation LTV (i.e., $L > 1/(1 - \tilde{\lambda}_t)$), the cell displays "–" indicating an infeasible configuration.

5.4 Days to Liquidation

When the net spread is negative (borrowing costs exceed staking yields), the Health Factor decays over time. The sheet calculates the number of days until the health factor decays to 1; i.e. days to liquidation.

5.4.1 Net Daily Rate

The net daily rate of Health Factor decay is:

$$r_{\text{net}} = r_{\text{stake}} - r_{\text{borrow}} - IR(u) \cdot \Psi \tag{15}$$

where Ψ is the CLP cost factor from Equation (5). When $r_{\text{net}} < 0$, the position loses value over time.

5.4.2 Days to Liquidation Formula

The Health Factor evolves as:

$$\text{HF}(t) = \text{HF}_0 \cdot \left(1 + \frac{r_{\text{net}}}{1 + r_{\text{borrow}}}\right)^{t/D} \tag{16}$$

where t is time in days and $D = 365$. Liquidation occurs when $\text{HF}(t) = 1$. Solving:

$$\boxed{T_{\text{liq}} = -D \cdot \frac{\ln(\text{HF}_0)}{\ln\left(1 + \frac{r_{\text{net}}}{1 + r_{\text{borrow}}}\right)}} \tag{17}$$

Implementation Notes:

- If $r_{\text{net}} > 0$, the position is "SAFE" (Health Factor improves over time)
- The sheet uses a threshold of -0.00001 to handle floating-point precision
- The formula assumes continuous compounding approximated by daily steps

6 Secondary Calculations

6.1 Leverage Grid Interpolation

For the leverage-based yield matrices, leverage values are interpolated logarithmically:

$$L_k = 10^{\log_{10}(L^{\max}) - \frac{k}{19} \cdot \left(\log_{10}(L^{\max}) - \log_{10}(L^{\min})\right)} \tag{18}$$

This produces a logarithmic scale from $L^{\max} = 50$ down to $L^{\min} \approx 7.33$, which corresponds to LTV values from 0.98 to approximately 0.864.

6.2 Yield Improvement

The "Looped Net Farming Yield Improvement" section calculates the percentage improvement of the Twyne-boosted yield over a baseline:

$$\Delta Y = \frac{Y(\tilde{\lambda}_{t,i}, \text{HF}_j)}{Y(\tilde{\lambda}_e^C, \text{HF}_j)} - 1 \tag{19}$$

This quantifies the benefit of using Twyne credit delegation compared to a standard Aave position at the same Health Factor.

6.3 Raw Credit Delegation Rate

The raw credit delegation rate earned by CLPs is calculated based on the interest rate model from Whitepaper Section 5:

$$r_{\text{raw}} = u \cdot IR(u) \tag{20}$$

where $IR(u)$ is the Twyne interest rate function (see Section 7).

7 Interest Rate Model

The Twyne interest rate model (Whitepaper Section 5) determines the credit delegation rate as a function of utilization:

$$IR(u) = I_{\min} + \frac{I_0 - I_{\min}}{u_0} \cdot u + \left(I_{\max} - I_{\min} - \frac{I_0 - I_{\min}}{u_0}\right) \cdot u^{\gamma} \tag{21}$$

The CLP rate earned by Credit LPs is:

$$r_{\text{CLP,earned}} = u \cdot IR(u) \tag{22}$$

Key properties:

- At low utilization, rates are low to encourage borrowing
- As utilization approaches 100%, rates increase sharply (governed by γ)
- The high γ value (32) creates a steep rate curve near full utilization

8 Matrix Structure

8.1 Primary Yield Matrix (Rows 12–31, Columns G–P)

Table 6: Yield Matrix Structure

	Boosted Liquidation LTV			
Health Factor	95.0%	96.0%	97.0%	98.0%
1.10	$Y_{1,1}$	$Y_{1,2}$	$Y_{1,3}$	$Y_{1,4}$
1.09	$Y_{2,1}$	$Y_{2,2}$	$Y_{2,3}$	$Y_{2,4}$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
1.00	$Y_{20,1}$	$Y_{20,2}$	$Y_{20,3}$	$Y_{20,4}$

Each cell $Y_{j,i}$ is computed using Equation (7) with:

- $\tilde{\lambda}_t = \tilde{\lambda}_{t,i}$ from Equation (1)
- $\text{HF} = \text{HF}_j$ from Equation (2)

8.2 Days to Liquidation Matrix (Rows 12–31, Columns U–AD)

Mirrors the yield matrix structure but displays T_{liq} from Equation (17). Cells display "SAFE" when $r_{\text{net}} > 0$.

8.3 Leverage-Based Matrices (Rows 37–76)

Similar structure but rows are indexed by leverage values (Equation (18)) rather than Health Factor.

9 Interpretation Guide

9.1 Reading the Yield Matrix

Example: At HF = 1.10 and Boosted Liquidation LTV $\tilde{\lambda}_t = 95\%$, with default parameters ($\beta_{\text{safe}} = 0.85$, $\tilde{\lambda}_e^{\text{CLP}} = 0.95$, $\tilde{\lambda}_e^C = 0.95$):

$$\lambda_t = \frac{0.95}{1.10} \approx 0.864 \tag{23}$$

$$\Psi = \frac{0.95}{0.85 \cdot 0.95} - \frac{0.95}{0.95} = \frac{0.95}{0.8075} - 1 \approx 0.176 \tag{24}$$

$$Y = \frac{0.036 - 0.20 \cdot 0.864 - IR(u) \cdot 0.176}{1 - 0.864} \tag{25}$$

The operating LTV is $\lambda_t = 86.4\%$, and the CLP cost factor $\Psi \approx 0.176$ represents the ratio of credit that must be reserved per unit of borrower collateral. The overall yield depends on the Twyne interest rate $IR(u)$ at the current utilization level.

9.2 Sensitivity Analysis

The matrix structure enables quick sensitivity analysis:

- **Moving right** (higher Boosted Liquidation LTV): Higher leverage, more CLP cost
- **Moving down** (lower Health Factor): Higher operating LTV (λ_t), more borrow cost
- **Changing r_{stake}**: Shifts entire matrix proportionally
- **Changing u**: Affects CLP cost factor (Ψ) non-linearly

9.3 Break-Even Analysis

The sheet can identify break-even conditions:

- Find the minimum staking rate for profitability at given HF/LTV
- Determine maximum tolerable borrow rate
- Identify optimal leverage point

10 Connection to Whitepaper

Table 7: Mapping to Whitepaper Sections

Sheet Concept	Whitepaper Section	Reference
Credit Delegation	Section 4	Equation 7 (credit reservation invariant)
Rebalancing Mechanics	Section 4.1	Rebalancing mechanics and triggers
Interest Rate Model	Section 5	Equation 9 (IR model)
CLP Loss Analysis	Section 7	Loss attribution and bad debt
Safety Buffer (β_{safe})	Section 4	Buffer parameter in Equation 7

11 Appendix: Cell Reference Map

Table 8: Complete Cell Reference Map

Cell	Variable	Formula/Value	Units
C11	$\tilde{\lambda}_e^C$	Liquidation LTV of borrower's collateral (C) on Aave	%
C12	$\tilde{\lambda}_t^{\max}$	Twyne max Boosted Liquidation LTV	%
C13	r_{stake}	Staking + lending rate	% APR
C14	r_{borrow}	Aave borrow rate	% APR
C17	$\text{HF}^{\max}$	HF axis upper bound	dimensionless
C18	$\text{HF}^{\min}$	HF axis lower bound	dimensionless
C34	$\tilde{\lambda}_e^{\text{CLP}}$	Liquidation LTV of CLP collateral on Aave	%
C35	$r_{\text{CLP,lend}}$	CLP lending rate on Aave	% APR
C36	$1-\beta_{\text{safe}}$	Complement of safety buffer	%
C38	$IR(u)$	Twyne credit delegation IR	% APR
C39	$r_{\text{CLP,total}}$	Total CLP rate	% APR
C50	$L^{\max}$	Input	$\times$
C51	$L^{\min}$	Input	$\times$
C55	D	365	days
G11:P11	$\tilde{\lambda}_{t,i}$	Eq. (1)	%
F12:F31	HF_j	Eq. (2)	dimensionless
G12:P31	$Y_{j,i}$	Eq. (7)	% APR
U12:AD31	T_{liq}	Eq. (17)	days

12 Appendix: Formula Verification

To verify the spreadsheet formulas match this documentation:

12.1 Yield Formula (Cell G12)

```
=(C13 - C14*(G11/F12) - C38*((G11/((1-C36)*C34)) - (C11/C34)))
 / (1 - (G11/F12))
```

Corresponds to Equation (7) with:

- `C13` $= r_{\text{stake}}$ (staking + lending rate)
- `C14` $= r_{\text{borrow}}$ (Aave borrow rate)
- `G11` $= \tilde{\lambda}_t$ (Boosted Liquidation LTV)
- `F12` $=$ HF (health factor)
- `C38` $= IR(u)$ (Twyne credit delegation interest rate)
- `C36` $= 1-\beta_{\text{safe}}$ (so `1-C36` $= \beta_{\text{safe}}$)
- `C34` $= \tilde{\lambda}_e^{\text{CLP}}$ (liquidation LTV of CLP collateral on Aave)
- `C11` $= \tilde{\lambda}_e^C$ (liquidation LTV of borrower's collateral on Aave)

12.2 Days to Liquidation Formula (Cell U12)

```
=IF(-C55*LOG(T12)/LOG(1+(C13-C14-C38*((U11/((1-C36)*C34))
  -(C11/C34)))/(1+C14)) >= -0.00001,
  -C55*LOG(T12)/LOG(1+(C13-C14-C38*((U11/((1-C36)*C34))
  -(C11/C34)))/(1+C14)),
  "SAFE")
```

Corresponds to Equation (17) with the "SAFE" condition when $T_{\text{liq}} < 0$ (i.e., positive net rate).