Twyne V1 - Litepaper

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1 Introduction

Twyne is a noncustodial, risk-modular credit delegation protocol implemented for the Ethereum Virtual Machine. By integrating with established lending DeFi markets, Twyne unlocks levels of capital efficiency which currently are not possible due to both the balkanization of liquidity across lending protocols and the presence of unused borrow demand within them. Twyne creates a new trustless primitive that allows lenders across established lending markets to electively take on higher risks in exchange for higher yields without shouldering any new risks onto lending market participants that do not desire to interact with Twyne. By doing so, Twyne enables borrowers to access on-demand higher collateral factors and cross-lending market market operations. We argue that this creates higher flexibility for borrowers, selective risk/yield trade-offs for credit lenders, as well as higher capital utilization rates for all the lending markets integrated through Twyne. We believe Twyne's democratic value-additive experience to be the next step towards demonstrating the potential for DeFi to unlock levels of credit liquidity currently unavailable in traditional finance.

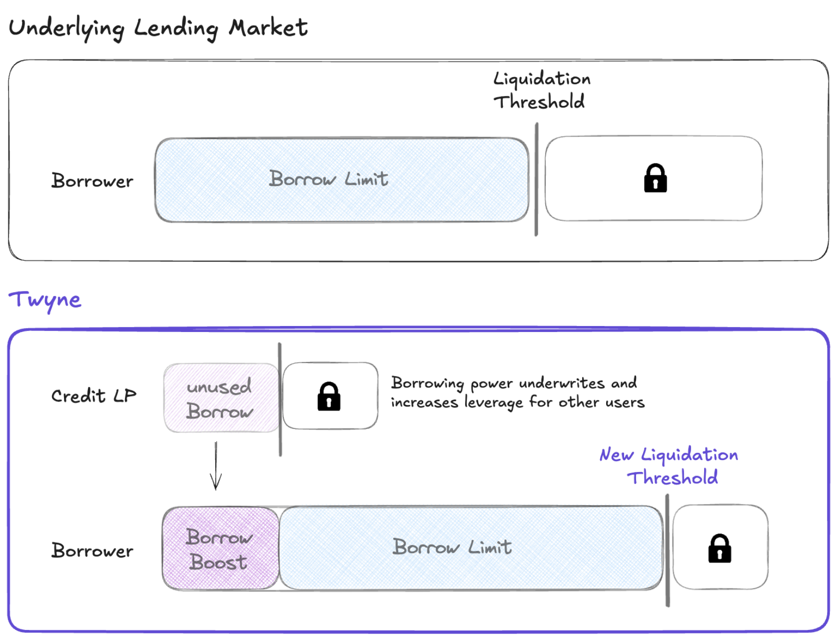

Figure 1: Comparison of borrowing limits for Borrowers operating through Twyne and established Lending Markets. By tapping into the unused borrowing power of other users (Credit LPs), a Borrower can boost their borrow limit while still accessing the same lending market liquidity, and satisfying its security cosntraints.

2 Protocol Entities

At its core, Twyne is a marketplace that aggregates unused borrowing power across established DeFi lending protocols. A market can thus be created for lending such borrowing power to borrowers wishing to access liquidity of lending markets on loan terms exceeding what is possible at the liquidity's source. Two crucial entities define the Twyne protocol. Whereas a specific user can in theory occupy a combination of these roles, we will initially describe them in their purest form. In what follows, by *lending market* we will always imply an established DeFi lending protocol that exists externally and independently of Twyne.

2.1 Credit LPs (CLPs)

A Credit LP (CLP) is a lending market user which lends assets in exchange for yield but does not use these assets as collateral to borrow anything against them. A CLP simply expects yield for their lending efforts and is satisfied with the security assumption of the lending market their assets currently sit in. A CLP chooses to stake their lending market receipt tokens into Twyne to rent their assets' unused borrowing power to users willing to pay for them. At no point does the CLP wish for a borrower to come into possession of the CLP's underlying assets unless mediated by the explicit security assumptions of the lending market those underlying assets were deposited into.

2.2 Borrowers

As in all lending markets, a Borrower is a user willing to use their own assets as collateral to negotiate an over-collateralized loan with some liquidity source. A Borrower is willing to pay a continuous market interest for said loan and, beyond maintaining a healthy *loan-to-value ratio* (LTV), is under no obligation to repay their loans unless desired. A Borrower understands that should their LTV exceed some liquidation threshold, a liquidation may ensue whereby their entire position is terminated in an effort to make lenders whole.

2.3 Twyne V1 Mechanic Overview and Definitions

Twyne allows CLPs from established lending markets to stake their deposit tokens onto Twyne. In doing so, they retain all lending yield earned on their lending market of origin, while simultaneously allowing Twyne's mechanics to delegate their borrowing power in the interest of generating higher yields. A Borrower can choose to access this borrowing power to access a liquidation LTV λ_{twyne}^{liq} of their choosing, which is higher than that supported by the external lending market λ_{ext}^{liq}. This is achieved by using the borrowing power of the CLP's assets C_{LP} to back a larger loan than would be allowed outside of Twyne. For the purpose of Twyne V1, the assets provide by CLPs are identical in type to those provided by the Borrower as collateral to ensure that only one type of λ_{ext}^{liq} needs to be tracked.

We shall denote by C, B, and C_{LP} the borrower's supplied collateral, their outstanding external borrow, and outstanding CLP collateral being reserved respectively. These quantities, which define the Borrowers portfolio at any given moment, accrue interest from/to the external lending market. The amount of the external loan B accrues the interest owed at the borrowing rate established by the external lending market. Similarly, C and C_{LP} also earn the loan yield paid out by the external lending market. In addition, interest is paid directly to C_{LP} as an interest rate r_C paid out of the collateral of the borrower C (discussed in Section 4) to account for the beneficial utilization of the CLP funds. From a user's collateral and borrow assets, we will define their Twyne LTV as:

$$\lambda_{\text{twyne}} = \frac{B}{C}. \tag{1}$$

3 Credit Lending

A borrower's Twyne LTV (Equation 1) differs from the *external LTV* λ_{ext} attributed to the user by the external lending market providing the assets being borrowed:

$$\lambda_{\text{ext}} = \frac{B}{C + C_{LP}}, \tag{2}$$

where, at any given moment, the following relationship holds between λ_{ext} and λ_{twyne}:

$$\lambda_{\text{twyne}} > \lambda_{\text{ext}}. \tag{3}$$

Twyne thus allows the Borrower to tap into underlying lending market liquidity as if they had λ_{ext}, whereas λ_{twyne} may already be liquidatable on that external lending market. Twyne is responsible for imposing overcollateralization of the Borrower's true position and making sure that it is triggered before the underlying lending market flags it for liquidation. This responsibility can be formalized through two conditions which represent the portfolio safety conditions that must hold on Twyne:

$$\lambda_{twyne} \leq \lambda_{twyne}^{liq} \tag{4}$$

$$\lambda_{ext} \leq (1 - \beta_{safe}) \cdot \lambda_{ext}^{liq} \equiv \tilde{\lambda}_{ext}^{liq}. \tag{5}$$

Equation 4 states that liquidations are not triggered on Twyne unless the Borrower's LTV λ_{twyne} exceeds their liquidation LTV λ_{twyne}^{liq}. Equation 5 states that the external LTV λ_{ext} must, at all times, retain a buffer of safety β_{safe} with respect to the external liquidation threshold λ_{ext}^{liq}. Since the quantities on the right-hand side of Equation 5 occur often in our exposition, we redefine them using the variable $\tilde{\lambda}_{ext}^{liq}$ to simplify our notation. The equality in **both** safety conditions is allowed to occur **solely** when the Borrower is liable to be liquidated on Twyne ($\lambda_{twyne} = \lambda_{twyne}^{liq}$). When this occurs, the two safety conditions imply:

$$\lambda_{ext} = \frac{\lambda_{twyne}^{liq}}{1 + \frac{C_{LP}}{C}} = \tilde{\lambda}_{ext}^{liq}, \tag{6}$$

which can be used to express the CLP assets that must be reserved by the Borrower at any given moment to ensure the desired liquidation LTV λ_{twyne}^{liq}, given their instantaneous collateral size C:

$$C_{LP} = \left(\frac{\lambda_{twyne}^{liq}}{\tilde{\lambda}_{ext}^{liq}} - 1 \right) \cdot C. \tag{7}$$

The above condition is verified by Twyne's smart contracts whenever an interaction affects a user's portfolio. If the necessary C_{LP} are not available to be reserved by the Borrower, their total deposited collateral C or desired liquidation loan-to-value λ_{twyne}^{liq} must be capped to match available CLP funds.

4 Interest Rates

Twyne integrates three distinct interest rates: lending market yield, lending market borrow, and CLP supply rates. The first two guarantee that all assets delegated onto Twyne continue to earn/pay whatever yield is paid/charged by whichever underlying lending market an entity's assets reside in/derive from. The CLP supply rate is the rate at which a borrower's collateral is charged for reserving the borrowing power offered by CLPs. Twyne employs a curved interest rate model $IR(u)$ that depends solely on the asset-specific utilization rate of CLPs $u \equiv C_{LP}/C_{LP}^{total}$, each with its own asset specific parameters IR_0, u_0, IR_{max}, and γ:

$$IR(u) = \frac{IR_0}{u_0} \cdot u + \left(IR_{max} - \frac{IR_0}{u_0} \right) \cdot u^{\gamma}, \tag{8}$$

subject to consistency conditions:

$$IR_{max} > \frac{IR_0}{u_0} > 0$$
$$\gamma > 1$$
$$1 > u_0 > 0. \tag{9}$$

Figure 2 shows a couple of example curves plotted for various values of γ.

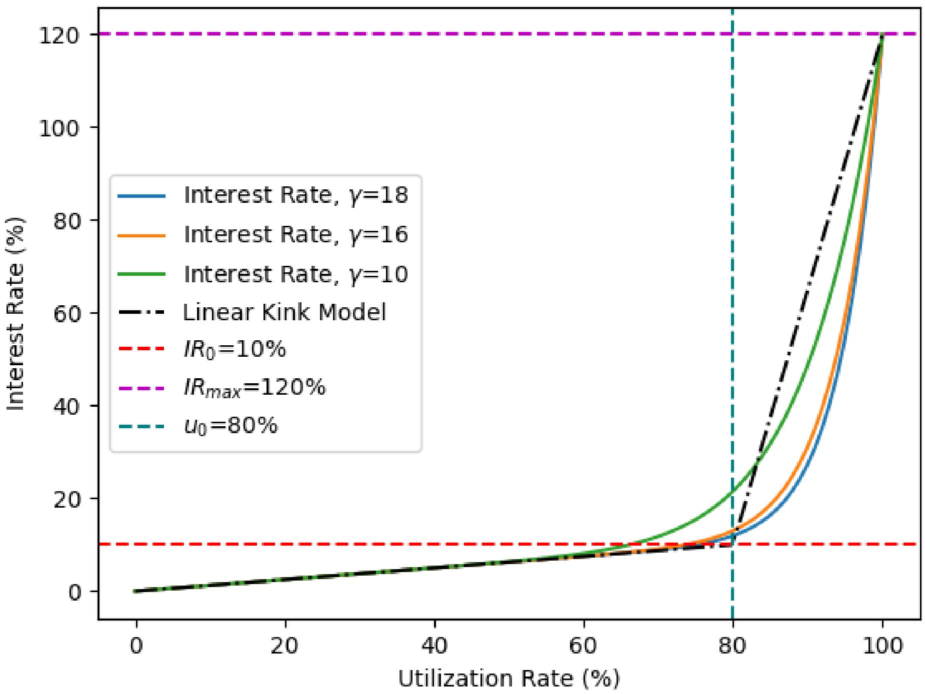

Figure 2: Sample Interest Rate curves for $IR_0 = 0.1$, $u_0 = 0.8$, $IR_{max} = 1.2$ and varying γ. Utilization and interest rates have been converted from decimals to percents.

The specific form of Equation 8 is designed to behave quasi-linearly for utilization rates $u_{asset} \leq u_0$, and polynomial ramp quickly to IR_{max} (with power γ) when the u_0 threshold is overcome. This interest rate curve, initially successfully deployed by the Keom Protocol [1], efficiently parametrizes the optimal 1D interest rate curves studied through Morpho's research efforts [2] without the need for complex on-chain operations or PID controllers. The parameters defining the precise shape of the interest rate model can be intuitively understood in relation to the more commonly used linear-kink model (black dot-dashed curve in Figure 2). The threshold utilization u_0 and the interest rate IR_0 represent the location and interest rate where the kink appears in the model. The choice of γ then controls how much the curved interest rate model overshoots IR_0 at the kink, as well as how much it lags the linear model at high utilization.

4.1 Borrower Siphoning Rate

From a borrower's perspective, their collateral experiences a yield that is the combination of a subtractive rate r_C paid to CLPs (termed the *siphoning rate*) and any positive lending yield accrued through the underlying lending market. Their borrow interest rate, on the other hand, coincides with whatever borrow rate is quoted by the underlying lending market for the assets being borrowed. The gross interest rate r_C paid to CLPs in units of collateral asset held by the Borrower, can be thought of as the ratio between the absolute interest payment owed on the CLP funds being reserved $C_{LP} \cdot IR(u)$ and the collateral C held by the borrower:

$$r_C = \frac{C_{LP} \cdot IR(u)}{C}. \tag{10}$$

However, a borrower will probably be more interested in the net rate r_C^{net} paid:

$$r_C^{net} = \frac{C_{LP} \cdot IR(u)}{C - B} = \frac{r_C}{1 - \lambda_{twyne}}. \tag{11}$$

4.2 CLP credit provisioning rate

Similarly, CLPs experience a combined lending rate which is the sum of the interest rate paid to them by borrowers accessing their borrowing power, as well as the underlying lending market's asset rate. Whereas the gross CLP rate is identical to the utilization-based rate $IR(u)$ defined in Equation 8, the net rate r_{LP}^{net} perceived will be the ratio between the gross payment and the total CLP assets supplied:

$$r_{LP}^{net} = \frac{C_{LP} \cdot IR(u)}{C_{LP}^{total}} = u \cdot IR(u). \tag{12}$$

5 Liquidations

When allowing users to take out over-collateralized loan, the success of the liquidation process is extremely important [3]. In traditional DeFi lending markets, liquidations must ensure that enough Borrower collateral can be repossessed such that it can be swapped to repay some portion of the outstanding loan as well as incentivizing the liquidator for the effort. This operation must be executed before asset prices move so much that insolvencies or toxic liquidation spirals derail the entire lending market [4]. This is a particularly sensititve matter on Twyne, given that it allows borrowers to access higher LTVs than what is allowed on external lending markets. To avoid such matters as much as possible, Twyne primarily adopts a *liquidation-through-inheritance* model.

Whenever a Borrower (*Alice*) is found to have an LTV greater than Twyne's defined liquidation threshold ($\lambda_{\text{twyne}} > \lambda_{\text{twyne}}^{liq}$), ANY user with collateral on Twyne can trigger an inheritance of the Borrower's entire position. If such a user is another borrower (*Bob*), then Bob will inherit all of Alice's collateral, her liabilities to external lending markets, and will retain the same CLP reserved assets (owing siphoning rate interest). Thus, after executing the liquidation and inheriting Alice's position, Bob's LTV on Twyne will become:

$$\lambda_{\text{twyne}}^{Bob} = \frac{B^{Bob} + B^{Alice}}{C^{Bob} + C^{Alice}}. \tag{13}$$

If the user executing the liquidation is a CLP (Charlie), they agree to become a borrower. In doing so, they engage some amount of their unutilized assets C_{LP}^{extra} as collateral, thus allowing the execution of a successful liquidation call. Charlie's LTV $\lambda_{twyne}^{Charlie}$ following the inheritance would become:

$$\lambda_{\text{twyne}}^{Charlie} = \frac{B^{Alice}}{C_{LP}^{extra} + C^{Alice}}. \tag{14}$$

In all cases, Twyne smart contracts check ahead of time that a liquidator has enough collateral on Twyne to safely execute the inheritance. The advantage of this model is two-fold. First, it attempts to retain as much capital on the protocol by attempting to make liquidators act as users first and foremost. Secondly, since the inheritance does not necessarily require a swap, a liquidation should be more easily executable by a wider array of entities.

5.1 Fallback Liquidations

In case of delay in executing the liquidation call, the underlying lending market Alice was borrowing from will trigger a liquidation which may in whole or in part affect Alice as well as any CLPs helping to back Alice's loan. In such a scenario we cannot know what the state of Alice's position will be subsequently to the external liquidation. What we can say is that, generally, there will be some amount of outstanding loan B^{left} and collateral C^{left} leftover. In these circumstances, the resized position will still belong to Alice but her share of collateral ownership $C^{\text{left}}_{\text{Alice}}$ relative to the CLPs' share $C^{\text{left}}_{\text{LP}}$, will be defined such that Alice remains liquidatable on Twyne:

$$
\begin{aligned}
C^{\text{left}}_{\text{Alice}} &= \frac{B^{\text{left}}}{\lambda^{liq}_{\text{twyne}}} && (15)\\
C^{\text{left}}_{\text{LP}} &= C^{\text{left}} - C^{\text{left}}_{\text{Alice}}. && (16)
\end{aligned}
$$

The above fallback process maximizes the amount of funds retrievable by the CLPs while still allowing an opportunity for Alice claw back some small share of her original funds. If the external liquidation liquidates all of Alice's loans, the remaining collateral will entirely belong to the CLPs backing Alice's loan.

References

[1] Keom Protocol Team. Curved interest rate model solidity implementation. https://github.com/keomprotocol/keom-contracts/blob/main/interest-rate-models/CurvedRateModel.sol, 2023. Accessed: Dec 23, 2023.

[2] Charles Bertucci, Louis Bertucci, Mathis Gontier Delaunay, Olivier Gueant, and Matthieu Lesbre. Agents' behavior and interest rate model optimization in defi lending. *Available at SSRN 4802776*, 2024.

[3] Kaihua Qin, Liyi Zhou, Pablo Gamito, Philipp Jovanovic, and Arthur Gervais. An empirical study of defi liquidations: Incentives, risks, and instabilities. In *Proceedings of the 21st ACM Internet Measurement Conference*, pages 336–350, 2021.

[4] Jakub Warmuz, Amit Chaudhary, and Daniele Pinna. Toxic liquidation spirals. *arXiv preprint arXiv:2212.07306*, 2022.