Fira Protocol: Fixed-Rate Infrastructure

Whitepaper — Version 1.0

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March 2026

Abstract

Fira is a decentralized lending and borrowing protocol that brings fixed-rate credit on-chain. While traditional financial markets support more than $145 trillion in fixed-rate instruments, over 99% of decentralized finance (DeFi) lending exposure remains floating-rate. This structural gap prevents borrowers from locking in funding costs, limits lenders to uncertain returns, and makes it difficult for treasuries to plan against known obligations.

Fira addresses this gap by introducing fixed-rate markets built around tradable zero-coupon bonds and separable, tradable yield, complemented by native floating-rate markets, internal rehypothecation of reserves, and multi-layer vault curation. Fixed-rate borrowing is implemented through Bond Tokens (BT), minted from overcollateralized positions and sold at a discount via a purpose-built automated market maker (AMM) whose pricing converges to par at maturity. Coupon Tokens (CT) isolate the yield component, enabling independent trading of implied fixed rates. Floating-rate markets provide the base layer for rehypothecation: idle reserves are deployed to generate additional yield, which is distributed to liquidity providers. Curated vaults allow professional allocators to deploy capital across both market types.

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1 Introduction

There is a structural gap in today's on-chain credit markets: most DeFi lending activity is mediated by variable-rate pools. Rates reset continuously as utilization changes, exposing retail users, institutions, and DAO treasuries to persistent interest-rate volatility. This makes it difficult to forecast cash flows, lock borrowing costs, or secure predictable lending returns over a defined horizon.

DeFi credit has grown to roughly $60 billion in total value locked, yet more than 99% of this exposure remains floating-rate [**?**]. These spot-rate markets provide no native notion of maturity and therefore no term structure. Participants cannot reliably manage duration or plan liabilities against known future obligations.

Fixed-rate instruments with explicit maturities do more than stabilize funding costs: they make interest-rate risk tradable. In traditional markets, liquid bonds across tenors anchor yield curves and enable rate positioning, hedging, and duration management at scale, with more than $145 trillion in outstanding fixed-rate credit globally [**?**]. By contrast, on-chain markets largely lack deep, long-dated instruments and the ability to trade implied rates along a curve.

Closing this gap requires moving from spot credit to maturity-based credit: markets where borrowers and lenders can lock terms, and where rates can be discovered and traded across maturities.

Fira aims to close this gap.

Fira is an autonomous on-chain credit protocol that enables fixed-rate lending and borrowing without intermediaries. Borrowers choose a maturity and obtain funding at a market-implied fixed rate formed through supply and demand. Rather than charging interest via an explicit coupon, Fira implements fixed-rate borrowing using zero-coupon *Bond Tokens* (BT): BTs are minted against overcollateralized positions and trade below par, so the borrower's effective rate is embedded in the discount, which converges to face value at maturity.

In addition to BT markets, Fira introduces *Coupon Tokens* (CT) as an experimental yield-trading primitive. Because Fira V1 does not initially support deep, long-tenor bond markets, CTs provide a practical way to express and trade yield: they separate the yield component from the principal, allowing participants to trade implied fixed rates without relying on long-dated bond liquidity. Complementing these fixed-rate markets, Fira also includes native floating-rate markets, internal rehypothecation of idle reserves, and multi-layer curated vaults—offering users a cohesive suite of on-chain credit instruments.

1.1 Why Fixed-Rate Protocols Historically Struggled

On-chain fixed-rate credit has historically struggled to scale, not because fixed rates lack demand, but because *maturity markets are hard to bootstrap.* A viable fixed-rate market must simultaneously offer (i) continuous issuance and pricing, (ii) credible early-exit optionality, and (iii) sustainable liquidity provision economics. Most designs achieved at most one of these properties, often relying on external incentives to fill the gap.

1.1.0.1 Two dominant implementation patterns. Fixed-maturity borrowing has typically been implemented through either auctions or AMM-based markets, each with distinct failure modes.

1.1.0.2 (1) Auction-based issuance: clears rates, but does not produce markets. Auctions can efficiently clear borrowers and lenders for a given maturity, but liquidity is erratic: rate discovery happens at discrete events and secondary exits are weak unless a separate market develops. This makes refinancing, hedging, and position management difficult, and participation often becomes incentive-driven rather than endogenous.

1.1.0.3 (2) AMM-based markets: continuous quotes, but LP economics do not close. AMMs can provide continuous pricing for fixed-maturity instruments, but the underlying flow is structurally *borrow-and-hold*. Most users borrow (sell the instrument) or lend (buy it) and then hold to maturity, which implies low secondary turnover and therefore limited fee revenue. Meanwhile, LPs must warehouse non-trivial risks (duration and inventory), often against one-directional flow (e.g., persistent bond selling from borrowers). The result is a reflexive failure mode: low trading → weak LP returns → thin liquidity → poor execution and early exits → even lower adoption.

1.1.0.4 What a sustainable design must solve. A fixed-rate protocol must not only match borrowers and lenders, but also create *rate trading*: two-sided activity that generates turnover and fees, improves exit optionality, and makes LP participation economically rational without perpetual subsidies.

1.1.0.5 How Fira addresses these constraints. Fira is designed around four complementary levers:

- **Continuous fixed-rate pricing via zero-coupon bonds (BT).** Fixed-rate borrowing is expressed through Bond Tokens (BT), which trade at a discount and converge to par at maturity, providing a clear pricing anchor for maturity-based credit.
- **Yield trading as a native primitive (CT).** Fira introduces Coupon Tokens (CT) as an experimental surface for *trading yield independently of principal.* This is especially important in Fira V1, where deep long-tenor bond markets are not yet available: CTs provide a practical way to express, hedge, and trade implied rates without requiring liquid long-dated bonds.
- **Baseline LP carry via internal rehypothecation.** Because fee revenue alone is insufficient in early-stage maturity markets, Fira complements trading fees with internal rehypothecation: idle reserves can earn floating-rate yield, which is distributed to liquidity providers to improve LP economics.
- **Liquidity aggregation and routing via curated vaults.** Curated vaults allow allocators to route capital across fixed-rate and floating-rate opportunities under explicit constraints, helping concentrate liquidity, maintain usable depth, and reduce the operational burden on end users.

Together, these mechanisms aim to turn fixed-rate credit from a thin, buy-and-hold product into a liquid on-chain rate market with credible exits and sustainable liquidity incentives.

2 Protocol Overview

Fira's architecture is organized into four interacting layers, each building upon the primitives defined by the layer below.

2.1 Architecture

Layer 1 — Token Primitives. Three core token types form the foundation of all Fira markets. Fira Wrapped tokens (FW) represent wrapped assets which are borrowable. Bond Tokens (BT) function as tradable zero-coupon bonds that redeem 1:1 at maturity. Coupon Tokens (CT) represent the yield component separated from the principal. The fundamental invariant is:

$$\mu(t)\ \text{USDC} = 1\ \text{FW-USDC} = \mu_s(t)\ \text{BT-USDC} + \mu_s(t)\ \text{CT-USDC}$$

where

$$\mu_s(t) = max(\mu(t), \mu_s(t*))$$

where $\mu(t)$ is the wrapping/unwrapping rate, $\mu_s(t)$ is the modified wrapping rate and t^* is the time of the last wrapping rate update (this is further detailled in sections 3.1.1).

Layer 2 — Market Layer. Two complementary market types operate on the token primitives. Fixed-rate markets use a purpose-built AMM (FiraMarket) that prices BT against FW, with implied rates discovered through trading activity. Floating-rate markets use utilization-based interest rate models with adaptive rate targeting, comparable to established DeFi lending protocols.

Layer 3 — Capital Efficiency. Rehypothecation allocates idle FW reserves into floating-rate markets to generate additional yield, which accrues to CT holders. Curated vaults allow professional allocators to deploy capital across both fixed-rate and floating-rate markets through multi-layer strategies.

Layer 4 — Risk and Safety. Overcollateralized positions, liquidation mechanisms, oracle infrastructure, and bad debt socialization provide the safety substrate. All parameters are governed by the DAO.

2.2 Dual Market Design

Fira natively supports both fixed-rate and floating-rate markets as first-class components. This dual design is not incidental — it is architecturally necessary. Floating-rate markets serve as the yield source for rehypothecation, creating a feedback loop where floating-rate lending generates the cash flows that make fixed-rate instruments more attractive. The two market types are complementary, not competing.

2.3 Smart Contract Infrastructure

Fira's implementation spans two primary repositories:

- **Fira** (fixed-rate AMM, token contracts, router): BondToken, CouponToken, USDCFW (FW implementation), FiraMarket (AMM), FiraRouterV4 (zapper), LiquidityInjector, RehypothecationModule.
- **Fira Lending Market** (lending engine, vaults, oracles): LendingMarket (multi-market lending engine), AdaptiveCurveIrm (floating-rate IRM), SisuVault (ERC-4626 curated vault), ChainlinkOracleV2 (oracle adapter).

The FiraRouter acts as a multi-call zapper, wrapping complex multi-step user flows (collateral deposit → BT borrow → swap → unwrap) into single atomic transactions through modular Action contracts.

3 Fixed-Rate Markets

Fixed-rate markets on Fira are implemented through tradable instruments built around Fira Wrapped assets and Bond Tokens, which function as zero-coupon bonds. Users borrow Bond Tokens through overcollateralized positions and exchange them for the underlying debt asset at a discount. Over time, as maturity approaches, the AMM facilitates price convergence such that each Bond Token trends toward the face value of the underlying asset. When the user repays the debt, this convergence allows the position to be closed at a predictable cost.

Together, these mechanisms allow users to borrow with a fixed maturity and lock in an interest rate, with the rate itself determined dynamically by market-driven supply and demand.

3.1 Fira Wrapped Tokens (FW)

Fira Wrapped tokens are wrapped representations of an underlying debt asset that allow users to seamlessly wrap and unwrap between the wrapped form and the native asset. While the wrapping framework is asset-agnostic, **Fira V1 initially operates exclusively with USDC**. The first wrapped asset is therefore FW-USDC, which serves as the unit of account for issuing fixed-rate loans.

The USDC collateral backing FW-USDC is held partly in liquid reserves and partly reinvested through rehypothecation (Section 5). As a result, the exchange rate between FW-USDC and USDC is not constant — it varies over time with the performance of the rehypothecated capital.

3.1.1 Wrapping Rate

At protocol initialization ($t = 0$), FW-USDC is issued at a 1:1 wrapping rate (also referred to as the unwrapping rate) with USDC. For $t > 0$, the wrapping rate reflects the ratio of total reserve value to the total FW-USDC supply:

$$\mu(t) = \begin{cases} 1 & \text{if } t = 0 \\ \dfrac{\text{Reserve}(t)}{\text{Supply}_{\text{FW}}(t)} & \text{if } t > 0 \end{cases}$$

where $\mu(t)$ denotes the unwrapping rate (USDC per FW-USDC). One unit of FW-USDC can be redeemed for $\mu(t)$ units of USDC, subject to available liquidity.

Borrowers receive FW-USDC, which can be unwrapped into standard USDC for external use. To repay loans, users must first rewrap USDC into FW-USDC before repayment.

3.2 Borrowing

Borrowing on Fira is implemented through tradable zero-coupon bonds. Users mint Bond Tokens (BT) through overcollateralized positions and then trade these tokens for the underlying debt asset, using FW tokens as an intermediary.

3.2.1 Loan Origination

The borrowing process follows four steps:

1. The user posts approved collateral.
2. The protocol mints BT-USDC backed exclusively by the collateral of that specific loan.
3. BT-USDC is immediately exchanged for FW-USDC through the Fira Market AMM at a discount.
4. FW-USDC is unwrapped into standard USDC.

In practice, the Fira Router executes the entire sequence atomically in a single transaction.

3.2.2 Zero-Coupon Bond Mechanics

BT-USDC is issued at a **face value of 1 USDC per token** and does not accrue additional interest. Repayment at any time prior to maturity requires returning the original number of BT-USDC tokens borrowed, regardless of the amount of USDC received at origination.

The effective interest rate is not charged explicitly. It is embedded in the discount at which BT-USDC is initially swapped for USDC.

At the time of borrowing, BT-USDC typically trades below par (i.e., 1 BT-USDC $<$ 1 USDC). As maturity approaches, the market price of BT-USDC converges to 1 USDC. The fixed cost of borrowing is thus the difference between the discounted USDC received at origination and the full BT-USDC principal repaid at maturity.

3.2.3 Fixed-Rate Guarantee

Because both the principal and the maturity date are fixed at origination, this mechanism implements a **fixed-rate loan when the position is held to maturity**. The borrower locks in both a fixed repayment amount and a fixed repayment date.

However, early repayment does not guarantee a fixed effective rate. Although repaying before maturity always requires fewer USDC than the maximum cost at maturity, the BT-USDC/USDC exchange rate varies over time. Any early repayment may lead to a higher or lower effective borrowing rate depending on the realized pre-maturity exchange rate.

3.3 Lending & Interest Rate Discovery

To facilitate borrowing, a FW-USDC/BT-USDC exchange mechanism is established through a liquidity pool. In this system, borrowers can swap their borrowed Bond Tokens (BT-USDC) for FW-USDC, which can then be unwrapped to USDC. On the other side of the pool, lenders are effectively users who provide FW-USDC in exchange for BT-USDC—either by directly purchasing BT-USDC or by supplying liquidity (which we term as Dynamic Lenders).

To construct this liquidity pool, Fira sources FW-USDC from liquidity providers (LPs). These FW-USDC deposits are then wrapped and deconstructed to mint Bond Tokens and Coupon Tokens (CT)—further explained in the *Yield Trading section*; this relationship is as follows:

$$1\ \text{FW-USDC} = \mu_s(t)\ \text{BT-USDC} + \mu_s(t)\ \text{CT-USDC}$$

where

$$\mu_s(t) = max(\mu(t), \mu_s(t*))$$

where t^* is the time of the last wrapping rate update.

LPs provide FW-USDC to the pool, which is split into BT-USDC and CT-USDC tokens according to the pool's current composition. The BT-USDC is used to facilitate borrowing, while the CT-USDC tokens remain with the LP and can be traded independently, as outlined in the *Yield Trading section.*

Further, the conversion rate differs between wrapping and deconstructing FW-USDC from USDC to BT-USDC and CT-USDC for proper socialization of bad debt loss (this is further explained in the *Bad Debt Accounting section*).

Once liquidity is added, interest rate discovery begins through the dynamics of the BT-USDC/FW-USDC exchange rate within the pool.

3.3.1 BT-USDC/FW-USDC Exchange Rate

Interest rate discovery in Fira is driven by the conversion rate between Bond Tokens (BT-USDC) and USDC. This rate—representing the amount of USDC receivable for one BT-USDC swapped—is used to compute the implied fixed borrowing rate as follows:

$$\text{borrowRate}(t) = \left(\frac{1 - conversionRate(t)}{conversionRate(t)}\right)^{\frac{1}{yearsToExpiry(t)}}$$

Where:

$$\text{yearsToExpiry}(t) = T - t$$

Given T represents the time to maturity (in years) from the launch of the pool (in contrast to the elapsed time since launch of the pool t).

The conversion rate depends on both the exchange rate between BT-USDC and FW-USDC, as well as the wrapping/unwrapping rate between USDC and FW-USDC. As such, the exchange rate is determined by an automated market maker (AMM), which sets the BT-USDC/FW-USDC price (i.e., how many BT-USDC can be obtained per FW-USDC) based on the pool's composition and parameters defined by the DAO. Thus, a user can first swap BT-USDC for FW-USDC (according to the exchange rate), and then unwrap FW-USDC to USDC (according to the wrapping rate). We define the conversion rate as follows:

$$\text{conversionRate}(t) = \frac{\mu(t)}{\text{exchangeRate}(t)}.$$

Moreover, the exchange rate already incorporates the wrapping rate, meaning we can simplify the expression and make the conversion rate independent of the wrapping rate. Specifically, the exchange rate for BT/FW is given by

$$\text{exchangeRate}(t) = \mu_s(t) \cdot \left(\frac{\ln\left(\frac{p(t)}{1-p(t)}\right)}{\text{rateScalar}(t)} + \text{rateAnchor}(t) \right).$$

Hence, the USDC/BT-USDC conversion rate reduces to

$$\text{conversionRate}(t) = \frac{\mu(t)}{\mu_s(t)} \cdot \left(\frac{\ln\left(\frac{p(t)}{1-p(t)}\right)}{\text{rateScalar}(t)} + \text{rateAnchor}(t) \right)^{-1}.$$

where:

$$p(t) = \frac{n_{\text{BT-USDC}}(t)}{n_{\text{BT-USDC}}(t) + n_{\text{USDC}}(t)}$$

where $n_{\text{BT-USDC}}(t)$ and $n_{\text{USDC}}(t)$ are the amounts of BT-USDC and FW-USDC in the pool at time t.

$$\text{rateScalar}(t) = \frac{\text{scalarRoot}}{\text{yearsToExpiry}(t)}$$

Here, scalarRoot is a liquidity concentration factor determined by the DAO.

$$\text{rateAnchor}(t) = \text{lastImpliedRate}^{\text{yearsToExpiry}(t)} - \frac{\ln\left(\frac{p(t^*)}{1-p(t^*)}\right)}{\text{rateScalar}(t)}$$

where t^* is the time of the most recent trade, and:

$$\text{lastImpliedRate} = (borrowRate(t*) + 1)^{\frac{1}{\text{yearsToExpiry}(t^*)}}$$

The lastImpliedRate is updated with each trade to reflect the most recent interest rate expectations.

Unlike traditional AMMs that use static pricing formulas (e.g., constant product), Fira's AMM dynamically evolves based on trading activity and demand for BT-USDC. As maturity approaches, the conversion rate is designed to converge to 1 USDC per BT-USDC (unless bad debt is incurred). This convergence ensures that BT-USDC accurately reflects its redeemable value at maturity.

We can express the convergence behavior as (assuming $\mu(t) = \mu_s(t)$ which is true unless bad debt has been incurred):

$$conversionRate(t) = \left(\frac{\ln\left(\frac{p(t)}{1-p(t)}\right)}{\text{rateScalar}(t)} + \text{rateAnchor}(t) \right)^{-1}$$

or, equivalently:

$$\text{conversionRate}(t) = \left(\frac{\ln\left(\frac{p(t)}{1-p(t)}\right) \cdot \text{yearsToExpiry}(t)}{\text{scalarRoot}} + \text{rateAnchor}(t) \right)^{-1}$$

As $t \to T$, we observe:

$$\lim_{t \to T} \frac{\ln\left(\frac{p(t)}{1-p(t)}\right) \cdot \text{yearsToExpiry}(t)}{\text{scalarRoot}} = 0$$

and thus:

$$\lim_{t \to T} \text{conversionRate}(t) = \lim_{t \to T} \text{lastImpliedRate}^{-\text{yearsToExpiry}(t)} = 1$$

In such case that bad debt is incurred within the fixed rate market, BT becomes less valuable relative to USDC, meaning the conversion rate converges to value below 1.

$$\mu(t) < \mu_s(t) \;\Rightarrow\; \lim_{t \to T} \text{conversionRate}(t) = \frac{\mu(t)}{\mu_s(t)} < 1$$

3.3.2 Maturity Settlement

To simplify loan repayment at maturity, users can mint BT-USDC using USDC (via FW-USDC). Conversely, holders of BT-USDC can redeem their tokens for USDC (also via FW-USDC) after maturity. This creates a robust primary market for loan settlement and avoids potential inefficiencies or liquidity shortages that might arise from relying solely on secondary market pricing through the AMM.

However, it should be noted that the wrapping rate is modified after maturity and is fixed based on the last wrapping rate before maturity. Therefore the loan technically accrues some minimal interest while users wait to repay after maturity. This comes from the difference between the actual wrapping rate (from USDC to FW-USDC) and the now fixed modified wrapping rate (from FW-USDC to BT-USDC and CT-USDC).

3.4 Yield Trading (Coupon Tokens)

Coupon Tokens (CT) are created exclusively when FW-USDC is decomposed into its two components: Bond Tokens (BT-USDC) and Coupon Tokens (CT-USDC). This decomposition typically occurs when a user supplies liquidity.

3.4.1 CT Trading via Flash Loans

Although the core liquidity pool operates on the BT-USDC/FW-USDC pair, CT-USDC trading is enabled indirectly through flash loan mechanisms executed atomically by the smart contracts:

Buy CT-USDC. The user initiates a flash loan to temporarily borrow FW-USDC. The total FW-USDC is decomposed into BT-USDC and CT-USDC. BT-USDC is swapped back into FW-USDC through the AMM to repay the flash loan. The user keeps the CT-USDC.

Sell CT-USDC. The user initiates a flash loan to borrow BT-USDC. The borrowed BT-USDC is combined with the user's CT-USDC to reconstruct FW-USDC. A portion of FW-USDC is swapped to BT-USDC to repay the flash loan. The user keeps the remaining FW-USDC.

All flash loans are sourced directly from the protocol's pools. The full sequence executes atomically within a single transaction.

3.4.2 LP Coupon Token Selling

Liquidity providers may choose to sell their idle CT-USDC back into the pool to extract value immediately. By doing so, they effectively recombine BT-USDC and CT-USDC, increasing the supply of FW-USDC available for borrowing. This allows LPs to realize the interest component early while simultaneously contributing additional liquidity to support further lending activity.

3.4.3 CT Valuation

The exchange rate of Coupon Tokens relative to USDC can be inferred from two observable quantities — the BT-USDC/FW-USDC exchange rate and the FW-USDC/USDC unwrapping rate:

$$\text{extractableValue}_{\text{CT}}(t) = \mu_s(t) \cdot \left(1 - \frac{1}{\text{exchangeRate}(t)}\right)$$

where $\mu_s(t)$ is the FW-USDC/BT+CT modified unwrapping rate and $\text{exchangeRate}(t)$ denotes the BT-USDC/FW-USDC rate in the AMM.

4 Floating-Rate Markets

While fixed-rate borrowing and lending is the primary focus of Fira, floating-rate markets are natively supported as a core component. Their inclusion serves two purposes: (1) providing standard variable-rate lending comparable to established DeFi protocols, and (2) furnishing the foundation for rehypothecation, where floating-rate yield is redirected to enhance returns on fixed-rate instruments.

4.1 Market Structure

Floating-rate markets on Fira are spot-rate markets with no fixed maturity:

- Lenders deposit assets into a pool and earn variable interest.
- Borrowers post overcollateralized positions and accrue interest continuously.
- Borrowers may repay at any time; lenders may withdraw subject to available liquidity.
- Each floating-rate market is defined by a specific debt asset and collateral pair.

The lend rate is derived from the borrow rate and utilization:

$$\text{Lend}_{\text{APR}} = \text{Borrow}_{\text{APR}} \times u(t)$$

Because both borrowing and lending rates are volatile, floating-rate markets are typically more suitable for short- to medium-term use.

4.2 Interest Rate Mechanism (IRM)

Spot borrowing rates in floating-rate markets are determined as a function of market utilization — the fraction of supplied liquidity that is currently borrowed.

4.2.1 Utilization

$$u(t) = \frac{\text{Borrow}(t)}{\text{Lend}(t)}$$

where Borrow(t) is the total assets borrowed and Lend(t) is the total assets supplied at time t.

4.2.2 Spot Borrowing Rate

Given utilization, the instantaneous spot borrowing rate $r(t)$ is:

$$r(t) = r_T(t) \cdot \text{curve}(u(t))$$

where $r_T(t)$ is the rate target and curve(u) is a static utilization curve.

4.2.3 Rate Target Dynamics

The rate target $r_T(t)$ represents the borrowing rate at target utilization u_{target}. It is initialized at market creation and evolves dynamically in response to utilization deviations. Let t^* denote the most recent update:

$$r_T(t) = r_T(t^*) \cdot \exp\bigl(k_p \cdot e\bigl(u(t^*)\bigr) \cdot (t - t^*)\bigr)$$

where k_p controls the speed of adjustment and $e(u)$ is the utilization error function:

$$e(u) = \begin{cases} \dfrac{u - u_{\text{target}}}{u_{\text{target}}} & \text{if } u \leq u_{\text{target}} \\ \dfrac{u - u_{\text{target}}}{1 - u_{\text{target}}} & \text{if } u > u_{\text{target}} \end{cases}$$

This function symmetrically scales deviations below and above the target utilization.

4.2.4 Utilization Curve

The utilization curve shapes how the spot rate responds to deviations from the target:

$$\text{curve}(u) = \begin{cases} \left(1 - \dfrac{1}{k_d}\right) \cdot e(u) + 1 & \text{if } u \leq u_{\text{target}} \\ (k_d - 1) \cdot e(u) + 1 & \text{if } u > u_{\text{target}} \end{cases}$$

where k_d controls the asymmetric slope of the curve. For $u > u_{\text{target}}$, the rate increases steeply, incentivizing repayment and discouraging further borrowing.

4.2.5 Rate Bounds

The spot borrowing rate is bounded:

$$r(t) = \max\big(\min\big(r_T(t) \cdot \mathrm{curve}(u(t)),\ r_{\max}\big),\ r_{\min}\big)$$

4.2.6 Global Parameters

All IRM parameters are set globally and may be modified through governance:

Parameter	Symbol	Description
Target utilization	u_{target}	Optimal utilization level
Adjustment speed	k_p	Rate of change of the rate target
Curve slope	k_d	Asymmetric slope parameter
Initial rate target	$r_T(0)$	Rate target at market launch
Minimum rate	$r_{\min}$	Lower bound on spot rate
Maximum rate	$r_{\max}$	Upper bound on spot rate

5 Rehypothecation

To enhance the yield earned by holders of Coupon Tokens, a portion of liquidity provided by LPs is allocated to a variable-rate vault managed internally by Fira. The interest generated from this rehypothecated liquidity is distributed to CT-USDC holders and becomes progressively claimable prior to the pool reaching maturity.

This process is governed by a reserve allocation model that controls how much FW-USDC remains liquid in the pool and how much is rehypothecated into the variable-rate vault.

5.1 Reserve Allocation Model

To manage the allocation of FW-USDC between liquid reserves and rehypothecated capital, we define a reserve ratio φ as the fraction of liquid (unrehypothecated) reserves relative to the total FW-USDC supply in the pool:

$$\varphi = \frac{\mathrm{USDC}_{\text{reserve}}}{\text{FW-USDC}_{\text{pool}}}$$

A target reserve ratio φ_{target} is defined, together with lower and upper tolerance bounds $\varphi_{\min}$ and $\varphi_{\max}$. The reserve ratio is recomputed at every market interaction. If the observed ratio falls outside the acceptable interval, the system automatically rebalances:

$$\text{if } \varphi \notin [\varphi_{\min},\ \varphi_{\max}] : \quad \varphi \leftarrow \varphi_{\text{target}}$$

5.1.1 Rebalancing Behavior

- If $\varphi < \varphi_{\min}$: the system withdraws FW-USDC from the variable-rate vault and returns it to the liquid reserve, restoring on-chain liquidity.
- If $\varphi > \varphi_{\max}$: the system deposits excess FW-USDC from the pool into the variable-rate vault to generate additional yield.

This mechanism ensures continuous balance between yield generation and liquidity availability for fixed-rate borrowing and redemptions.

5.1.2 Parameterization and Governance

All rehypothecation parameters are governed by the DAO. Parameter selection is informed by stress testing and quantitative modeling to ensure sufficient liquidity under adverse conditions. The primary design objective is to prevent scenarios in which a user is unable to borrow or redeem because an excessive fraction of reserves has been rehypothecated.

Key governance principles:

- The DAO prioritizes **liquidity availability and system safety** over maximal capital efficiency.
- Parameters are **conservative by design**, even if this reduces the amount of capital deployed into yield-generating strategies.
- Updates are expected no more than monthly or quarterly.
- Responsibility may later be delegated to a curator (trusted third party).

5.2 Coupon Token Yield Mechanics

CT-USDC entitles its holder to all interest generated by rehypothecation and is freely tradable in the fixed-rate markets. This dual role — representing a claim on floating-rate yield while trading in a fixed-rate market — creates nontrivial dynamics.

5.2.1 Interest Allocation

All interest earned by rehypothecated liquidity prior to maturity is distributed exclusively to outstanding naked CT-USDC (excluding any FW-USDC that could be decomposed into CT-USDC).

To measure accumulated interest, the protocol tracks the modified wrapping rateof FW-USDC into USDC which has a monotonicity constraint:

$$\mu_s(t) = \max\left(\frac{\text{Reserve}(t)}{\text{Supply}_{\text{FW}}(t)},\ \mu_s(t^*)\right)$$

where t^* denotes the most recent update. The monotonicity ensures that $\mu_s(t)$ is non-decreasing over time, preventing yield clawback from bad debt loss realization which would be realized in the actual wrapping rate $\mu(t)$ (see section 6.4.1).

The protocol records a snapshot of each user's CT-USDC balance and cumulative interest at every event that modifies CT-USDC ownership or supply (minting, burning, transfers, swaps).

5.2.2 Claimable Yield

The total claimable yield attributable to CT-USDC at time t is:

$$\mathrm{CT}_{\mathrm{claim}}(t) = \left(1 - \frac{\mu_s(t^*)}{\mu_s(t)}\right) \times \frac{\mathrm{Balance}_{\mathrm{CT}}(t)}{\mu_s(t*)}$$

This yield is distributed to CT-USDC holders proportionally to their token balances.

After maturity, CT-USDC no longer receives any share of rehypothecation yield. Only active markets continue to accrue and distribute interest.

5.3 CT Price Dynamics and Equilibrium

From a pricing perspective, CT-USDC is a hybrid instrument: its cash flows depend on a floating-rate market, while its trading venue is a fixed-rate market. The realized price from selling CT-USDC today may differ from the discounted present value of expected future yield from holding it to maturity.

5.3.1 Equilibrium Conditions

A price equilibrium for CT-USDC is achieved when the market price equals the discounted expected value of its remaining cash flows.

CT overpriced relative to cash flows. If the market price of CT-USDC exceeds the expected present value of remaining yield, rational agents sell CT-USDC. This reduces circulating supply, increases FW-USDC in the pool, allocates more capital to rehypothecation (increasing future cash flows to remaining CT holders), and exerts downward pressure on CT-USDC price.

CT underpriced relative to cash flows. If the market price is below expected future yield, rational agents buy CT-USDC. This increases circulating supply, reduces FW-USDC in the pool, decreases capital available for rehypothecation (lowering future cash flows), and exerts upward pressure on CT-USDC price.

Proposition (CT Equilibrium). *Although CT-USDC pricing depends simultaneously on floating-rate yield dynamics and fixed-rate market conditions, these opposing feedback mechanisms ensure that a stable price equilibrium exists. In equilibrium, the market price of CT-USDC equals the discounted expected value of its remaining rehypothecation yield.*

6 Liquidations

Borrowers are required to deposit collateral to borrow in both fixed-rate and floating-rate markets. This collateral must exceed the value of borrowed assets by a safety margin determined by the liquidation loan-to-value threshold (LLTV). If the collateral value relative to outstanding debt falls below this threshold, the position becomes eligible for liquidation.

6.1 Position Health

A borrower's position becomes liquidatable when collateral value falls below a critical threshold relative to the debt owed.

Definition (Loan-to-Value Ratio).

$$\mathrm{LTV} = \frac{\mathrm{Debt}}{\mathrm{Collateral}}$$

where Debt includes accrued interest, and Collateral is the oracle-valued amount expressed in units of the debt asset.

Definition (Health Factor).

$$H = \frac{\mathrm{LLTV}}{\mathrm{LTV}}$$

A position is healthy when $H \geq 1$. When $H < 1$, the position is unhealthy and becomes eligible for liquidation.

6.2 Oracles

Each market is configured with a specific oracle to value collateral relative to the debt asset. Three classes of oracles may be used:

Oracle Type	Description	Use Case
Price Feed	External feeds (Chainlink, Redstone)	Exchange rates between distinct assets
Exchange Rate	Deterministic oracles for wrapped/rebasing tokens	Tokens with known conversion rates
Fixed-Price	Constant price oracles	Stablecoins pegged to the same value

6.2.1 Bond Token Oracle

Bond Tokens are priced at face value of the underlying debt asset at all times. A Fixed-Price Oracle is used for all BT-denominated loans. For example, BT-USDC is always priced as 1 USDC when computing the LTV of fixed-rate borrowers, allowing all collateral to be valued directly in units of the underlying debt asset.

6.3 Liquidation Incentive Factor (LIF)

Liquidators are compensated through a Liquidation Incentive Factor that determines the bonus collateral awarded relative to debt repaid.

Definition (LIF).

$$\mathrm{LIF} = \min\left(\mathrm{LIF}_{\max},\ \frac{1}{\delta \cdot \mathrm{LLTV} + (1 - \delta)}\right)$$

where:

- $\text{LIF}_{\text{max}} = 1.15$ (maximum allowable incentive)
- $\delta = 0.3$ (sensitivity parameter)

Collateral Seized. Given a liquidation event:

$$\text{Collateral}_{\text{seized}} = \min\left(\text{Collateral},\ \text{LIF} \cdot \frac{\text{Debt}_{\text{repaid}}}{P_{\text{debt}}}\right)$$

where $\text{Debt}_{\text{repaid}}$ is the debt amount repaid by the liquidator and P_{debt} is the oracle price of the debt asset relative to collateral. Any remaining collateral after liquidation is returned to the borrower.

6.3.1 Alternative Liquidation Penalty

When liquidating users post grace period for fixed rate markets (see section 6.5), we actually do not use the LIF and instead set a fixed liquidation penalty per market. This allows the DAO to be relatively lenient and penalize borrowers less for missing repayment.

As a result, the alternative formula for collateral seized under the liquidation penalty is:

$$\text{Collateral}_{\text{seized}} = \min\left(\text{Collateral},\ (1 + \text{Liquidation}_{Penalty}) \cdot \frac{\text{Debt}_{\text{repaid}}}{P_{\text{debt}}}\right)$$

Additionally it should be noted that partial liquidations are not allowed post grace period.

6.3.2 Alternative Liquidation Price Oracle

In the case of bad debt (such that $\mu_s(t) > \mu(t)$), the price of debt relative to collateral P_{debt} is inflated slightly to penalize the borrower less for bad debt.

$$P_{modified} = P_{debt} \times \frac{\mu_s(t)}{\mu(t)}$$

By increasing price of debt relative to the collateral, the liquidator seizes fewer collateral tokens per unit of debt repaid. This prevents over-seizure — borrowers don't lose more collateral than the debt is actually worth given the vault's bad debt impairment.

6.4 Bad Debt

Bad debt occurs when a borrower's collateral cannot be liquidated for enough value to fully repay the outstanding debt. This occurs when a user's LTV reaches $1/LIF$ (or using the liquidation penalty for post-grace period). The resulting shortfall — after accounting for price impact, slippage, fees, and other execution costs — constitutes bad debt loss.

6.4.1 Bad Debt Socialization

Bad debt loss is socialized among lenders. The mechanism differs by market type:

Fixed-Rate Markets. Bad debt is reflected through the modified wrapping rate $\mu_s(t)$. If bad debt is incurred, the actual wrapping rate $\mu(t)$ decreases (due to a reserve reduction) while the modified rate $\mu_s(t)$ remains constant at the pre-loss level:

$$\mu_s(t) = \max(\mu(t),\ \mu(t^*))$$

This socializes the loss across LPs and holders of BT and CT. Users holding FW-USDC experience value loss through the decreased wrapping rate.

Floating-Rate Markets. Floating-rate markets use a vault share price for deposits:

$$P_{\text{vault}} = \frac{\text{Owed} + \text{Unutilized}}{\text{Shares}}$$

where Owed is the total borrowed amount plus accrued interest and Unutilized is the total idle supply. When bad debt is incurred, the owed portion decreases by more than the unutilized portion increases, reducing the vault share price proportionately.

6.5 Forced Liquidation at Maturity

Fira supports forced liquidation at maturity, even if a position is otherwise healthy. This is intentional for a maturity-based collateral lifecycle: when the collateral's maturity timestamp is reached, all remaining positions can be closed to enable collateral redemption.

7 Curation

Curation refers to the active allocation and oversight of lender capital within a vault. Lenders deposit assets into curated vaults to earn yield passively, while a designated curator manages capital deployment. The curator determines which markets are accessible, defines asset allocations, and establishes risk constraints. In return, curators earn fees charged to vault depositors.

Curated vaults may deploy capital across both fixed-rate and floating-rate markets, enabling more flexible and capital-efficient strategies than either market type alone.

7.1 Curator Responsibilities

A curator's role centers on strategic direction and risk governance rather than day-to-day execution:

Responsibility	Description
Strategy Definition	Establishing the vault's investment mandate: eligible assets, protocols, and market types
Risk Framework Design	Setting and maintaining exposure caps, concentration thresholds, and liquidity buffers
Allocator Appointment	Designating an allocator for portfolio adjustments within the predefined strategy
Vault Parameter Control	Defining fee structures, access controls, and compliance requirements

Most curator-initiated changes are subject to a **timelock**, ensuring transparency and providing depositors sufficient time to withdraw if they disagree with proposed modifications. Curator permissions can be revoked if a curator fails to manage responsibly.

7.2 Multi-Layer Curated Vaults

Fira's curated vaults support multi-layered allocation strategies across both market types:

Market Type	Allocation Mechanisms
Fixed-rate markets	Liquidity provision, CT-USDC purchases, BT-USDC positions
Floating-rate markets	Direct vault deposits

This design space allows curators to construct strategies accounting for:

- **Duration** — matching maturity profiles to depositor expectations.
- **Cash flow characteristics** — balancing predictable fixed-rate returns with variable floating-rate yield.
- **Liquidity conditions** — ensuring sufficient withdrawal capacity at all times.
- **Cross-market dynamics** — exploiting arbitrage opportunities between fixed and floating-rate markets.

8 Risk Management

Fira addresses risks across three primary dimensions: technology, product, and collateral. This section provides a structured overview of identified risks and their mitigations. These disclosures are not exhaustive.

8.1 Technology Risk

Technology risk encompasses vulnerabilities inherent in smart contract systems: coding errors, bugs, and potential exploits.

Mitigations:

- Three independent external audits (Sherlock, Spearbit/Cantina, yAudit) plus an extended internal review.
- Continuous smart contract monitoring by internal and third-party services.
- Transparent proxy patterns enabling upgrade capability for critical fixes.
- Pause guardian and emergency shutdown procedures.

8.2 Product Risk

8.2.1 Fixed-Rate Market Risk

Fixed-rate markets provide predictable borrowing and lending by shielding users from rate volatility. However, users who settle positions before maturity face price risk and potential liquidity constraints.

The BT-USDC exchange rate varies with market conditions, and early exits may result in realized rates that diverge from entry rates.

Mitigation: Fira sets liquidity concentration parameters ensuring the majority of liquidity is provided within a defined implied rate range, establishing a predictable price corridor.

8.2.2 Floating-Rate Market Risk

When utilization reaches 100%, the spot rate rises to the upper bound and the target rate begins increasing exponentially. Borrowing costs can rise by several multiples within a 24–48 hour period.

Mitigation: Curators actively manage liquidity buffers and asset allocations. The adaptive IRM automatically adjusts the rate target to incentivize rebalancing.

8.2.3 Rehypothecation Risk

When FW-USDC is deposited into a fixed-rate pool, a portion of underlying USDC reserves is allocated to a floating-rate market. Part of the FW-USDC becomes temporarily illiquid. Borrowers may be unable to withdraw USDC if large borrowing activity or LP withdrawals consume remaining reserves.

Mitigation: Conservative rehypothecation parameters ($\varphi_{\text{target}} = 90\%$) prioritize liquidity availability over yield maximization. The design explicitly accepts lower capital efficiency in exchange for reliable operations.

8.2.4 Curation Risk

Curators may mismanage funds through excessive risk-taking, improper allocation, insufficient liquidity buffers, or poorly defined exposure limits.

Mitigation: Rigorous vetting process. Curators must demonstrate substantial experience managing significant capital. All parameter changes are subject to timelocks. Permissions are revocable by governance.

8.3 Collateral Risk

Bad debt arises when collateral value falls below outstanding debt. Only pre-approved assets are accepted, with thorough evaluation of fundamentals, liquidity profile, historical performance, and volatility. Accepted collateral is continuously monitored and may be removed from the eligible list if conditions deteriorate.

9 Conclusion

Decentralized finance has achieved remarkable scale in lending and borrowing, yet its credit infrastructure remains structurally incomplete. With over 99% of on-chain lending exposure locked into floating-rate mechanisms, DeFi lacks the foundational primitives — fixed rates, maturities, and term structures — that underpin traditional financial markets globally.

Fira addresses this gap by building the fixed credit layer of DeFi. Through tradable zero-coupon bonds (Bond Tokens), separable yield instruments (Coupon Tokens), a dynamically evolving AMM with provable convergence at maturity, and internal rehypothecation that connects fixed-rate and floating-rate markets, Fira V1 delivers a complete credit infrastructure:

- **Borrowers** lock their cost of capital at origination through a fixed maturity and a rate determined by market-driven price discovery.
- **Lenders** purchase Bond Tokens at a discount and receive known returns at maturity, or provide dynamic liquidity through the AMM to earn trading fees.
- **Yield traders** access the implied fixed rate and rehypothecation yield directly through Coupon Tokens, enabling strategies that were previously unavailable on-chain.
- **Curators** deploy capital across both market types through multi-layer vaults, constructing duration-aware, risk-managed strategies.

Fixed-rate credit is not a niche product. It is the foundation upon which traditional finance was built. Fira brings that foundation on-chain.

10 Disclaimer

This document is provided for informational purposes only and does not constitute financial, legal, or investment advice. The information contained herein is subject to change as the Fira protocol evolves through governance.

Fira is a non-custodial DeFi protocol carrying substantial financial exposure. Interaction with the protocol may result in partial or total loss of funds. Users should conduct their own research and risk assessment before using any Fira product.

Smart contract audits reduce risk but do not eliminate it. The protocol is subject to technology risk, product risk, collateral risk, governance risk, and oracle model risk. Past performance of any product does not guarantee future results.

All parameters, rates, and configurations described in this paper reflect the state at the time of writing and may be modified.

11 References

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12 Appendix A: Notation Index

Symbol	Description	Defined in
$\mu(t)$	FW-USDC/USDC unwrapping rate	Section 3.1

Symbol	Description	Defined in
$\mu_s(t)$	Modified wrapping rate (gross of bad debt)	Section 3.3
$p(t)$	Pool proportion of BT-USDC	Section 3.3
$n_{\mathrm{BT}}(t)$	Quantity of BT-USDC in the pool	Section 3.3
$n_{\mathrm{FW}}(t)$	Quantity of FW-USDC in the pool	Section 3.3
$\tau(t)$	Time to maturity: $T - t$ (in years)	Section 3.3
T	Maturity timestamp	Section 3.3
scalarRoot	Liquidity concentration parameter (DAO-set)	Section 3.3
rateScalar(t)	scalarRoot$/\tau(t)$	Section 3.3
rateAnchor(t)	Rate continuity anchor	Section 3.3
lastImpliedRate	Most recent implied rate (updated per trade)	Section 3.3
conversionRate(t)	BT-USDC to USDC conversion rate	Section 3.3
borrowRate(t)	Implied annualized fixed borrow rate	Section 3.3
$u(t)$	Utilization ratio (floating-rate markets)	Section 4.2
u_{target}	Target utilization	Section 4.2
$r(t)$	Spot borrowing rate (floating-rate markets)	Section 4.2
$r_T(t)$	Rate target	Section 4.2
k_p	Rate target adjustment speed	Section 4.2
k_d	Utilization curve slope parameter	Section 4.2
$e(u)$	Utilization error function	Section 4.2
curve(u)	Static utilization curve	Section 4.2
φ	Reserve ratio (rehypothecation)	Section 5.1
$\varphi_{\mathrm{target}}$	Target reserve ratio	Section 5.1
$\varphi_{\mathrm{min}}, \varphi_{\mathrm{max}}$	Reserve ratio bounds	Section 5.1
$\mathrm{CT}_{\mathrm{claim}}(t)$	Claimable yield for CT holders	Section 5.2
LTV	Loan-to-Value ratio	Section 7.1
LLTV	Liquidation Loan-to-Value threshold	Section 7.1
H	Health factor	Section 7.1
LIF	Liquidation Incentive Factor	Section 7.3
$\mathrm{LIF}_{\mathrm{max}}$	Maximum liquidation incentive	Section 7.3
δ	LIF sensitivity parameter	Section 7.3