

Perpetual Rates: A Mathematical Framework for Continuous-Tenor Interest Rate Swaps On-Chain

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The interest rate swap is the largest derivatives market in the world, with roughly \$539 trillion in notional outstanding as of mid-2025 and 81% of all interest-rate derivatives.¹ Its market structure has changed little in four decades. Contracts are organized around a discrete grid of benchmark tenors, so a participant who needs exposure between two standard maturity points has to approximate it, roll it, and re-hedge as the position ages. This paper develops a framework, CIRCA, for building interest rate swaps on blockchain settlement infrastructure. The goal is not to reproduce the existing instrument in a new venue but to improve on it: exposure can be taken at any point on the curve rather than a fixed grid, and a position can hold its duration indefinitely instead of rolling down toward expiry.

RESULTS

The main results are proved formally and checked against the full history of SOFR:

- (i) **A persistent-duration / DVO1 result** formalizing continuous exposure. The position's rate sensitivity does not decay toward a maturity date, which has no direct analog in the TradFi market.
- (ii) **A manipulation-profit bound** on the embedded benchmark rate and settlement mechanism.
- (iii) **A capital-efficiency result**: a 15-40% improvement over the cleared bilateral equivalent, under stated book conditions.
- (iv) **An explicit initial-margin framework** with a defined margin period of risk.

APPROACH

The framework uses the standard fixed-income toolkit: spline-based curve construction on an embedded benchmark rate, duration and DVO1 analysis, funding-basis reasoning, and margin methodology. What is new is the setting, a market that does not yet have that infrastructure. This is the same work I did in RMBS pricing and prepayment/OAS modeling at Invictus Capital Partners, applied here to instrument design. The empirical sections are implemented in Python against historical SOFR data from FRED.

WHAT THE PAPER DOES NOT CLAIM

A few things sit outside what the math can settle. Legal enforceability under ISDA documentation, counterparty KYC and whitelisting, and institutional eligibility are all real prerequisites, and none of them follow from the protocol design. The paper makes the quantitative case for moving interest-rate risk on-chain. It does not claim the surrounding legal and regulatory stack is already in place.

Working paper, about 20,000 words. Draft v0.3

¹ Figures are from the BIS OTC derivatives statistics for end-June 2025 and ISDA's January 2026 review of the first half of 2025, which put interest rate swap notional outstanding at \$539.1 trillion, or 81.0% of interest rate derivatives.