Rates Guide

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Supply and Borrow Rates

How are rates calculated?

Variable Borrow Rate The variable borrow rate is determined is determined programatically based on the interest rate strategy for a reserve. The InterestRateStrategy for each reserve can be queried from theAaveProtocolDataProvider orUiPoolDataProvider view contracts.

Whenever an action occurs on a reserve (supply, borrow, repay, withdraw, liquidation, etc.)updateInterestRates is called. Most reserves implement theDefaultInterestRateStrategy which updates variable borrow rates based on the variable rate slope parameters determined by Aave Governance and borrow utilitization of the reserve.

An exception to this is the Aave GHO facilitator which uses a custom implementation of the interest rate strategymore details . Stable Borrow Rate The stable borrow rate (for new borrows) is determined programatically based on the interest rate strategy for a reserve. The InterestRateStrategy for each reserve can be queried from theAaveProtocolDataProvider orUiPoolDataProvider view contracts.

Whenever an action occurs on a reserve (supply, borrow, repay, withdraw, liquidation, etc.)updateInterestRates is called. All stable borrow reserves implement theDefaultInterestRateStrategy which updates stable borrow rates based on the stable rate slope parameters determined by Aave Governance and borrow utilitization of the reserve.

The rate for each active stable borrower is stored in a mapping and can be queried from thegetUserStableBorrowRate function.

In certain conditions, the stable borrow rate for a borrower can be rebalanced, see theFAQ for specific requirements in Aave V2 and V3. Supply Rate The supply rate is determined is determined programatically based on the interest rate strategy for a reserve. The InterestRateStrategy for each reserve can be queried from theAaveProtocolDataProvider orUiPoolDataProvider view contracts.

Whenever an action occurs on a reserve (supply, borrow, repay, withdraw, liquidation, etc.)updateInterestRates is called. The supply rate isupdated based on the weighted average of all variable and stable borrow rates minus the reserve factor, which is the percentage of borrow interest to the DAO treasury collector, determined by Aave Goveran

How is yield accrued?

Variable Borrow Balances Variable borrow balances increase over time, based on a checkpointing variable calledvariableBorrowIndex :

```

Copy VariableDebtToken.balanceOf(user) = VariableDebtToken.scaledBalanceOf(user) *
Pool.getReserveData(underlyingTokenAddress).variableBorrowIndex

```

where

```

Copy VariableDebtToken.scaledBalanceOf(user) = initialBorrowAmount / variableBorrowIndexAtTimeOfBorrow

```

variableBorrowIndex is shared across all variable borrowers and isupdated on all reserve state updates (supply, borrow, withdraw, repay, liquidate, etc.) based on the current variable borrow rate and time since last update.

ThevariableBorrowIndex can be queried from thePool.getReserveData(underlyingTokenAddress) ,AaveProtocolDataProvider.getReserveData(underlyingTokenAddress) , orUiPoolDataProvider.getReservesData() functions.

In Aave V3, all VariableDebtTokens contain a functiongetPreviousIndex which can be used to calculate accrued interest:

```

Copy initialBorrowedAmount = VariableDebtToken.scaledBalanceOf(user) * VariableDebtToken.getPreviousIndex(user) accruedInterest = VariableDebtToken.balanceOf(user) - initialBorrowedAmount

Stable Borrow Balances[](https://docs.aave.com/developers/guides/rates-guide#stable-borrow-balances)

Copy StableDebtToken.balanceOf(user) = StableDebtToken.principalBalanceOf(user) * accuredInterest

```

whereStableDebtToken.principalBalanceOf(user) is the initial borrow amount andaccruedInterest is calculatedhere based on the rate and last update timestamp of an individual address.

The rate and lastUpdateTimestamp for each active stable borrower are stored in mappings and can be queried from thegetUserStableBorrowRate andgetUserLastUpdated functions respectively. Supply Balances The checkpointing for supply balances occurs through theliquidityIndex variable:

```

Copy AToken.balanceOf(user) = AToken.scaledBalanceOf(user) * Pool.getReserveData(underlyingTokenAddress).liquidityIndex

```

where

```

Copy AToken.scaledBalanceOf(user) = initialSupplyAmount / liquidityIndexAtTimeOfSupply

```

liquidityIndex is a variable shared across all suppliers and isupdated on all reserve state updates (supply, borrow, withdraw, repay, liquidate, etc.) based on the current supply rate and time since last update.

TheliquidityIndex can be queried from thePool.getReserveData(underlyingTokenAddress) ,AaveProtocolDataProvider.getReserveData(underlyingTokenAddress) , orUiPoolDataProvider.getReservesData() functions.

In Aave V3, all ATokens contain a functiongetPreviousIndex which can be used to calculate accrued interest:

```

Copy initialSuppliedAmount = AToken.scaledBalanceOf(user) * AToken.getPreviousIndex(user) accruedInterest = AToken.balanceOf(user) - initialSuppliedAmount

```

How to query live data?

JavaScript SDK The Aave Utilities SDK is an extension of ethers v5, which simplifies the process of querying Aave Protocol data through a blockhain RPC:

Fetch Data

Format Data On-Chain Live rates can queried from thePool ,AaveProtocolDataProvider , orUiPoolDataProvider smart contracts.

TheAave Address Book is a registry of all protocol contract addresses.

Rates queried from contracts are in RAY units (10^27) and arenot compounded , seeformatting rates to convert to compounded percentage form. Subgraph The protocol subgraphs are indexed GraphQL endpoints which can be used to query current reserve states.

Subgraph rates come directly from smart contracts: RAY units (10^27) and arenot compounded , seeformatting rates to convert to compounded percentage form.

Reserve Query

```

Copy { reserves { name underlyingAsset

liquidityRate stableBorrowRate variableBorrowRate } }

```

User Data Query (for stable borrow data)

```

Copy

{ userReserves(where: {user: "insert_lowercase_address_here"}){ reserve{ symbol } stableBorrowRate stableBorrowLastUpdateTimestamp } }

```

How to query historical data?

Historical data for parameters, rates, and balances can be queried through contract events or indexed data sources.

A breakdown of all core protocol events can be foundhere .

TheAave Protocol subgraphs are an example of an indexed data source that maps contract events to a GraphQL endpoint.

Reward Emissions

Thisdocumentation explains the process of reward emissions.

Formatting Rates

All rates and indeces queried on-chain or from subgraphs are expressed in RAY units i.e. 10^27.

Supply and borrow rates queried on-chain or from subgraphs arenot compounded (APR). On the smart contract, borrow rates arecompounded per second using a binomial approximation (APY). Within each update action, supply rates are appliedlinearly , however, on an inter-action basis they experience the same compounding effect as the borrow ratesmore details .

The Aave Utilities SDKformatting functions (used on the app.aave.com interface) computes thecompounded supply and borrow rates using the formula shown below.

Incentive emissions are alwaysnon-compounded , they are applied to the scaled supply or borrow balance.

APR -> APY

To convert the APR (non-compounded) to APY (compounded per second), the formula is:

! A P Y = (1 + (A P R / s e c o n d s P e r Y e a r)) s e c o n d s P e r Y e a r – 1 APY = (1 + (APR / secondsPerYear))^{secondsPerYear} - 1 where the APY and APR are in decimal form (i.e. 2.5% = 0.025)

Weighted Average APY Weighted Average APY is the single-sided (supply or borrow) affect of rates on an addresses positions. It is calculated as the sum of((positionBalanceUSD * positionAPY) / totalBalanceUSD) for each position that an address holds.

Example:

Address supplies 100USD of WETH @ 2% and 200USD of WBTC @ 5%.

Weighted Average Supply APY = ((100 * 0.02) / (100 + 200)) + ((200 * 0.05) / (100 + 200)) = 0.04 = 4% Net APYNet APY is the impact of supplyand borrow rates on net worth (totalSupplied - totalBorrowed). It is an estimate of how much net worth

will change after one year of current rates.

The Net APY can be higher or lower than the individual weighted average APYs, this is most noticeable when the ratio oftotalSupplied tonetWorth is large.

The forumla is:

netAPY = ((weightedAverageSupplyAPY * totalSuppliedUSD) / netWorthUSD) - ((weightedAverageBorrowAPY * totalBorrowedUSD) / netWorthUSD)

Example:

Address supplies 100USD of WETH @ 2% and 200USD of WBTC @ 5%.

Weighted Average Supply APY = ((100 * 0.02) / (100 + 200)) + ((200 * 0.05) / (100 + 200)) = 0.04 = 4%

Address borrows 75USD of GHO @ 4% and 100USD of WETH @ 3%

Weighted Average Borrow APY = ((75 * 0.04) / (75 + 100)) + ((100 * 0.03) / (75 + 100)) = -0.03428 = 3.428%

Net Worth = (100 + 200) - (75 + 100) = 125USD

Net APY = ((0.04 * 300) / 125) + ((-0.03428 * 175) / 125) = 0.096 - 0.048 = 0.048 = 4.8%

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