Abstract

This post aims to introduce a new Interest Rate Model for Maker, the Fintegrate Rate Engine (FiRE). Its goal is generating optimal Base Rates which depend on the real economy, centralized exchanges, and Maker's collateral dynamics. The way this model will be implemented makes it possible to change the suggested parameters at any time. The final goal of the model is the automation of Stability Fees through an oracle-based implementation.

In short, the FiRE generates the Base Rate using a Low-Risk Rate (the 3M T-bills) at 0% Crypto Exposure (percentage of DAI backed by crypto collateral) which increases until Target Crypto Exposure, where it will be equal to the Benchmark Rate (the funding rates on CEXs), scaled by a multiplier. After the Target Crypto Exposure, the rate increases at a larger rate, to reach a maximum (in this case 50%) at 100% Crypto Exposure. The final output of the model will be the Base Rate, which will then be used to calculate Stability Fees and various borrowing rates across AllocatorDAOs as part of the Endgame.

[

1189×690 53 KB

](//makerdao-forum-backup.s3.dualstack.us-east-1.amazonaws.com/original/3X/c/7/c7a192edba2c465c65b535f98b730d7bb8bae35f.png)

The resulting stability fees will be the generated Base Rate plus spreads for different Liquidation Ratios and Vault Types or other future factors depending on the activity of AllocatorDAOs.

Since we believe this would be an innovative approach to stability fee calculation, we are requesting the community's feedback to comment, criticize, praise, or question this model, in order to improve it and make it a unique example in the DeFi landscape. This would put the protocol in the position of rate "maker" and not rate "taker".

We are requesting the community's feedback over the following points:

1. Choice of the implemented input parameters, namely:
2. the 3m T-bills as the Low-Risk Rate
3. 50% BTC and 50% ETH Average of Daily Annualized Funding Rates on Binance as the Benchmark Rate
4. the percentage of DAI backed by crypto collateral as the Crypto Exposure
5. Choice of the smoothing technique used to stabilize the generated Base Rates.
6. Choice of the Minimum and Maximum Rate used to bound Base Rate spikes.
7. Choice of the implementation of the Base Rate into Stability Fees calculation.
8. Anything else related to the model itself.

The following post addresses different aspects of the model that you can explore in detail.

Introduction and rationale

Maker has always been the reference point for DeFi rates. As an example, AAVE has adjusted GHO's borrow rate and the Slope parameters of its markets based on the changes in DSR (Proposal 1, Proposal 2, Proposal 3…). Exposure to crypto collateral is a very important parameter for Maker, since it can affect peg stability and profit estimation, by affecting the average yield that could be earned by the protocol.

Over the past year, Maker's approach to stability fees can be categorized into three phases:

- Adjustment of the Stability Collateral Yield Benchmark and Yield Collateral Yield Benchmark
- Adjustment based on the Exposure Model
- Adjustment based on external rate environment

The first approach was unsuccessful because it relied solely on the Yield Collateral Yield Benchmark and the Stability Collateral Yield Benchmark, ignoring the potential external rates achievable in crypto markets. This oversight could result in DAI losing its peg. The second approach, while more accurate, failed to react promptly to sudden changes. The third approach, which successfully priced in borrow rates, presents a philosophical challenge for the Maker protocol and cannot be automated.

In the DeFi ecosystem, this protocol is viewed as the rate "maker", setting a standard that others should follow for rate expectations as the largest source of liquidity. However, the latest approach positions the protocol, to a certain extent, as a rate "taker".

Consequently, BA Labs is proposing a new framework for stability fee calculation that would position the protocol as a leader in DeFi rate management and in general be more reactive to the external rate environment. This framework would be responsive to developments in the real economy, centralized exchanges, and Maker itself. We suggest naming this framework the Fintegrate Rate Engine (FiRE), as it integrates various financial dimensions with the goal of becoming an automated, oracle-based model during the Endgame Initiative.

FiRE - The new Interest Rate Model

Language Definition

The parameters used to define the model will be the following:

- Target Crypto Exposure (TCE

): this is the target exposure to crypto collateral in the MakerDAO protocol.

- Minimum Rate (MinR

): the minimum rate set by the governance for any given interest rate environment.

- Maximum Rate (MaxR

): the maximum rate set by the governance for any given interest rate environment.

- Low-Risk Rate (LR

): the starting rate for any given exposure level.

- Benchmark Rate (BR

): the optimal rate at target exposure.

- Crypto Exposure (CE

): the current amount of DAI backed by crypto collateral in percentage terms.

- Multiplier (m

): a number used to affect the impact of the benchmark rate.

[

1189×690 53 KB

](//makerdao-forum-backup.s3.dualstack.us-east-1.amazonaws.com/original/3X/c/7/c7a192edba2c465c65b535f98b730d7bb8bae35f.png)

Selection of Input Parameters

The input parameters used in the model are the following:

- Target Crypto Exposure (TCE

): 0.75

- Minimum Rate (MinR

): max(0.01, LR)

- Maximum Rate (MaxR

): 0.50

- Low-Risk Rate (LR

): 3-M Treasury Bill EMA

- Benchmark Rate (BR

): Daily Average Annualized Funding Rate EMA

- Crypto Exposure (CE

): Percentage of DAI Backed by Crypto Collateral EMA

- Multiplier ('m'): 0.9

Model Behavior

The model behavior can be described by the following function:

[

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D%20%3D%20k%20%2B%20m_1%20%5Ccdot%20%5Ctext%7BCE%7D%20%2B%20%5Cfrac%7B(m_2%20-%20m_1)%20%5Ccdot%20(%5Ctext%7BCE%7D%20-%20%5Ctext%7BTCE%7D)%7D%7B1%20%2B%20e%5E%7B-n%20%5Ccdot%20(%5Ctext%7BCE%7D%20-%20%5Ctext%7BTCE%7D)%7D%7D#0)

Where:

- [

](https://www.codecogs.com/eqnedit.php?latex=k#0) is a constant, the Starting Rate

- [

](https://www.codecogs.com/eqnedit.php?latex=m_1#0) is the Slope 1 parameter

- [

](https://www.codecogs.com/eqnedit.php?latex=m_2#0) is the Slope 2 parameter

- [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BCE%7D#0) is the Crypto Exposure

- [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BTCE%7D#0) is the Target Crypto Exposure, the Kink

- [

](https://www.codecogs.com/eqnedit.php?latex=n#0) is a smoothing factor

The calculation of the parameters is the following:

- [

](https://www.codecogs.com/eqnedit.php?latex=k%20%3D%20%5Ctext%7BLR%7D#0)

- [

](https://www.codecogs.com/eqnedit.php?latex=m_1%20%3D%20m%20%5Ccdot%20%5Cfrac%7B%5Ctext%7BBR%7D%20-%20%5Ctext%7BLR%7D%7D%7B%5Ctext%7BTCE%7D%7D#0)

- [

](https://www.codecogs.com/eqnedit.php?latex=m_2%20%3D%20%5Cfrac%7B%5Ctext%7BMaxR%7D%20-%20%5Ctext%7BLR%7D%20%2B%20m%20%5Ccdot%20(%5Ctext%7BLR%7D%20-%20%5Ctext%7BBR%7D)%7D%7B1%20-%20%5Ctext%7BTE%7D%7D#0)

- [

](https://www.codecogs.com/eqnedit.php?latex=n%20%3D%20700#0)

Some additional risk parameters ensure the following:

- If [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBR%7D%20%3C%20%5Ctext%7BLR%7D#0) then [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D%20%3D%20%5Ctext%7BLR%7D#0)

- If [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BLR%7D%20%3C%20%5Ctext%7BMinR%7D#0) then [

](https://www.codecogs.com/eqnedit.php?latex=k%20%3D%20%5Ctext%7BMinR%7D#0)

- If [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D%20%3E%20%5Ctext%7BMaxR%7D#0) then [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D%20%3D%20%5Ctext%7BMaxR%7D#0)

You can read more about the calculation of the input parameters below.

Exponential Moving Average (EMA) Calculation

While investigating the Input Parameters, it was clear that some kind of mathematical adjustment had to be done. The volatility of the selected Benchmark Rate makes it infeasible to be inputted directly into the model. At the same time, the selection of the span for the EMA is also an object of discussion, since this would have to be tweaked manually by the governance every time a change is needed.

To offset these issues, this is the proposed methodology for the EMA calculation. Let us define a general EMA at time [

](https://www.codecogs.com/eqnedit.php?latex=t#0):

[

](http://www.texrendr.com/?eqn=%5Ctext%7BEMA_t%7D%20%3D%20%5Calpha%20%5Cdot%20%5Ctext%7BY_t%7D%20%2B%20(1%20-%20%5Calpha)%20%5Cdot%20%5Ctext%7BEMA_%7Bt-1%7D%7D#0)

Where [

](https://www.codecogs.com/eqnedit.php?latex=%5Calpha#0) is calculated as:

[

](https://www.codecogs.com/eqnedit.php?latex=%5Calpha%20%3D%20%5Cfrac%7B2%7D%7BN%20%2B%201%7D#0)

We can see that as [

](https://www.codecogs.com/eqnedit.php?latex=N#0) increases, [

](https://www.codecogs.com/eqnedit.php?latex=%5Calpha#0) decreases, placing less weight on the last data point. While the methodology aims to smooth out the volatility of the Benchmark Rate, it is also necessary to place more weight on the last data point when the volatility is larger, meaning:

Larger volatility ([

](https://www.codecogs.com/eqnedit.php?latex=%5Csigma#0)) → Less data points ([

](https://www.codecogs.com/eqnedit.php?latex=N#0)) → Larger [

](https://www.codecogs.com/eqnedit.php?latex=%5Calpha#0)

This can be achieved through the following adjustment. Let us define a minimum number of data points ([

](https://www.codecogs.com/eqnedit.php?latex=N_%7Bmin%7D#0)) and a maximum ([

](https://www.codecogs.com/eqnedit.php?latex=N_%7Bmax%7D#0)). Furthermore, [

](https://www.codecogs.com/eqnedit.php?latex=%5Csigma#0) is calculated as the 90-day rolling standard deviation of the Benchmark Rate. We also suggest adding a multiplier [

](https://www.codecogs.com/eqnedit.php?latex=a#0) to make the function more sensitive to volatility changes. In this case, the [

](https://www.codecogs.com/eqnedit.php?latex=N#0) that will be inputted into the EMA will be:

[

](https://www.codecogs.com/eqnedit.php?latex=N%20%3D%20%5Cfrac%7BN_%7Bmax%7D%20%2B%20a%20%5Ccdot%20%5Csigma%20%5Ccdot%20N_%7Bmin%7D%7D%7B1%20%2B%20a%20%5Ccdot%20%5Csigma%7D#0)

This is a very efficient bounding mechanism, since if [

](https://www.codecogs.com/eqnedit.php?latex=%5Csigma%20%5Cto%20%5Cinfty#0) then [

](https://www.codecogs.com/eqnedit.php?latex=N%20%5Cto%20N_%7Bmin%7D#0), while if [

](https://www.codecogs.com/eqnedit.php?latex=%5Csigma%20%5Cto%200#0) then [

](https://www.codecogs.com/eqnedit.php?latex=N%20%3D%20N_%7Bmax%7D#0).

Target Crypto Exposure (TCE

)

As defined by the Maker Governance.

Minimum and Maximum Rate (MinR

, MaxR

)

The minimum and maximum rates are used to handle extreme cases where, for example:

- the Low-Risk Rate < 0.01,
- the Benchmark Rate > 0.50

The governance sets these two parameters.

Low-Risk Rate (RF

)

The Low-Risk Rate is set as the EMA of the 3-M Treasury Bills Yield. Mathematically:

[

](http://www.texrendr.com/?eqn=LR%20%3D%20%5Ctext%7BEMA_%7Bt%7D%7D%20%3D%20%5Calpha%20%5Cdot%20(%5Ctext%7BT-Bills_%7Bt%7D%7D)%20%2B%20(1%20-%20%5Calpha)%20%5Cdot%20%5Ctext%7BEMA_%7Bt-1%7D%7D#0)

Data source is the Federal Reserve Bank of st. Louis

Benchmark Rate (BR

)

The Benchmark Rate is set as the square root of the EMA of a daily equally weighted annualized funding rate between ETH and BTC. The mathematical transformations applied to achieve the Benchmark Rate are the following:

1. Retrieve the 8h funding rate for ETH and BTC
2. Take the arithmetic mean of the three 8-h rates measured per day (24h / 8h = 3 data points)
3. Multiply by the annualization factor 1095 (365 × 3).
4. Add the BTC and ETH daily annualized funding rates and divide by two.
5. Take the corresponding EMA.
6. The Benchmark Rate is the square root of the EMA minus 1.

Mathematically, the Benchmark Rate is:

[

](http://www.texrendr.com/?eqn=BR%20%3D%20(%5Csqrt%7B%5Ctext%7BEMA_t%7D%20%2B%201%7D)%20-%201#0)

Data source is Binance.

Crypto Exposure (CE

)

Crypto Exposure is set as the EMA of the percentage of DAI backed by crypto collateral, mathematically:

[

](http://www.texrendr.com/?eqn=CE%20%3D%20%5Ctext%7BEMA_%7Bt%7D%7D%20%3D%20%5Calpha%20%5Cdot%20(%5Ctext%7BCrypto%20Backed%20Dai_%7B%25t%7D%7D)%20%2B%20(1-%5Calpha)%20%5Cdot%20%5Ctext%7BEMA_%7Bt-1%7D%7D#0)

Data source is Makerburn.

Multiplier (m

)

The Multiplier is a factor used to scale the impact of the Benchmark Rate at target exposure, which in principle is used to price stability fees slightly lower than the Benchmark Rate. This is in order to give Maker more room for competitive advantage even at slightly higher Crypto Exposure after the Target Exposure is reached.

This parameter is currently set at 0.9, meaning that at Target Exposure, stability fees will be 10% cheaper than the Benchmark Rate.

Stability Fee Calculation

The Base Rate calculated, would be a rate on top of which applying the Liquidation Ratio Spreads or other speads such as Asset Specific Spreads. So, let's suppose a 5% Base Rate then, under the current language, Stability Fees for ETH vault types would be:

ETH-A = Base Rate + Balanced Liquidation Ratio Spread = 5% + 0.25% = 5.25%

ETH-B = Base Rate + Low Liquidation Ratio Spread = 5% + 0.75% = 5.75%

ETH-C = Base Rate + High Liquidation Ratio Spread = 5% + 0% = 5%

Model Assessment

Descriptive statistics

For this study, we considered 1575 data points, from 27 November 2019 to 24 May 2024.

In the analyzed period, the descriptive statistics of the original non-adjusted and adjusted input parameters were the following:

Variable

Benchmark Rate

Low-Risk Rate

Crypto Exposure

Adj Benchmark Rate

Adj Low-Risk Rate

Adj Crypto Exposure

Mean

16.51%

2.17%

49.65%

15.84%

2.09%

47.90%

Min

-124.32%

-0.05%

15.23%

-4.20%

0.02%

20.66%

25%

4.58%

0.09%

27.17%

5.96%

0.09%

26.81%

Median

10.09%

1.17%

42.25%

10.39%

0.64%

41.85%

75%

14.40%

4.95%

67.98%

18.41%

4.80%

60.99%

Max

239.55%

5.36%

100%

99.24%

5.30%

100%

Standard Deviation

27.80%

2.24%

26.16%

17.46%

2.24%

23.90%

For the last eight months, these are the six-month rolling correlations among the adjusted parameters. We can observe a positive correlation between Crypto Exposure and the Benchmark Rate, which is expected, as the positive sentiment reflected in funding rates is mirrored in Maker users opting for larger crypto exposures. Conversely, the negative correlations of the Low-Risk Rate with both Crypto Exposure and the Benchmark Rate are evident. This suggests that as Federal Reserve interest rates decline, investors turn to alternative yield sources, which in turn positively affect crypto prices, funding rates, and crypto exposure.

[

1038×699 54.8 KB

](//makerdao-forum-backup.s3.dualstack.us-east-1.amazonaws.com/original/3X/f/a/fa657ac684f0b0b65c01b987d2576c93719fdf17.png)

Historical Backtesting

We first show the time series of input parameters and compare them to the historical Stability Fees for the ETH-C vault.

[

1156×545 70.6 KB

](//makerdao-forum-backup.s3.dualstack.us-east-1.amazonaws.com/original/3X/3/6/3611bb502e2020fb72c165c709e2bab7eaeeb0ad.png)

We will now show the Interest Rates backtested during the same period and plotted against the actual stability fees experienced by Maker vaults' users:

[

1010×545 34.6 KB

](//makerdao-forum-backup.s3.dualstack.us-east-1.amazonaws.com/original/3X/b/a/ba782fedad83eee0f7d5475d9fbdd5e4a0d57870.png)

When "zooming-in" the last 8 months, we can clearly see (even though in hindsight) that the model would have returned an Interest Rate that when applied to Stability Fees could have avoided the need for the "Accelerated Proposal". The model would have signaled the need for a rate spike already in the second half of February, potentially enhancing the protocol's sustainability.

[

1010×545 30.6 KB

](//makerdao-forum-backup.s3.dualstack.us-east-1.amazonaws.com/original/3X/8/b/8bc5f88dbfaf73809a6f021a4d37df3491db9d27.png)

Elasticity Analysis

It is interesting to analyze the elasticities of the generated Interest Rates with respect to the input parameters.

The elasticity, with respect to the Low-Risk Rate, shows a linear increase, suggesting that the Base Rate becomes more sensitive to the Low-Risk Rate as the latter increases. On the other hand, with respect to the Benchmark Rate, shows a sharp increase after it becomes larger than the Risk-Free Rate, but then stabilizes at ~50%. The elasticity of Interest Rate to Crypto Exposure, shows an initial increase in elasticity as Crypto Exposure increases, peaking at Target Exposure before rapidly declining.

[

989×1489 70.1 KB

](//makerdao-forum-backup.s3.dualstack.us-east-1.amazonaws.com/original/3X/d/a/da99952d833221ad3c14ff5500b5dd26118ef52f.png)

Scenario Analysis

We will now analyze different scenarios under the following circumstances. Let's first define some baseline parameters used for scenarios, namely the average historical values:

- [

](https://www.codecogs.com/eqnedit.php?latex=LR_%7Bbaseline%7D#0) is 2.09%

- [

](https://www.codecogs.com/eqnedit.php?latex=CE_%7Bbaseline%7D#0) is 47.90%

- [

](https://www.codecogs.com/eqnedit.php?latex=BR_%7Bbaseline%7D#0) is 15.84%

The scenarios that will be simulated are the following:

1. High Funding Rates Scenario: Assumes a significant increase in the funding rates, perhaps due to market volatility or increased demand for borrowing.
2. [

](https://www.codecogs.com/eqnedit.php?latex=BR#0) is 150%

1. Low Treasury Bill Yields Scenario: Reflects a situation where yields on Treasury bills are low, possibly due to a shift in monetary policy.
2. [

](https://www.codecogs.com/eqnedit.php?latex=LR#0) is 0.5%

1. Negative Treasury Bill Yields Scenario: Reflects a situation where yields on Treasury bills are negative, as we have witnessed in 2015 and 2020:
2. [

](https://www.codecogs.com/eqnedit.php?latex=LR#0) is -0.2%

1. High Crypto Exposure Scenario: Considers the case where the Maker has an unusually high exposure to cryptocurrencies, increasing the risk profile.
2. [

](https://www.codecogs.com/eqnedit.php?latex=CE#0) is 95%

1. Negative Funding Rates Scenario: Assumes a significant decrease in the funding rates, perhaps due to market volatility or decreased demand for borrowing.
2. [

](https://www.codecogs.com/eqnedit.php?latex=BR#0) is -50%

1. Negative Treasury Bill Yields & Funding Rates Scenario: Assumes a significant decrease in the funding rates and Treasury Bills Yield.
2. [

](https://www.codecogs.com/eqnedit.php?latex=LR#0) is -0.2% and [

](https://www.codecogs.com/eqnedit.php?latex=BR#0) is -50%

1. Combined Stress Scenario: Combines all the above conditions to assess the model under a highly stressed market environment.
2. [

](https://www.codecogs.com/eqnedit.php?latex=BR#0) is 150% and [

](https://www.codecogs.com/eqnedit.php?latex=LR#0) is 0.5% and [

](https://www.codecogs.com/eqnedit.php?latex=CE#0) is 95%

Which results in the following Base Rates:

1. High Funding Rates Scenario: [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D#0) is 37.87%

1. Low Treasury Bill Yields Scenario: [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D#0) is 5.05%

1. Negative Treasury Bill Yields Scenario: [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D#0) is 4.80%

1. High Crypto Exposure Scenario: [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D#0) is 42.14%

1. Negative Funding Rates Scenario: [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D#0) is 2.09%

1. Negative Treasury Bill Yields & Funding Rates Scenario: [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D#0) is 1.00%

1. Combined Stress Scenario: [

](https://www.codecogs.com/eqnedit.php?latex=%5Ctext%7BBase%20Rate%7D#0) is 50%

Conclusion

This model was conceived to become a standard for Interest Rate management in the DeFi space, as it integrates trends at the both macroeconomic and protocol level. By incorporating the suggested parameters, we believe we would be able to propose stability fees that would mirror the market status correctly, in order to minimize the risk of having emergency situations or and/or further accelerated proposals.

What is important to point out is that this model can be tweaked to reflect new parameters based on the market environment. Let's suppose that the governance would decide to consider an alternative financial product as the Low-Risk Rate; this can be done by simply changing the Low-Risk Rate calculation methodology.

Furthermore, once the Endgame will get into the later stages, this model has the potential to become fully automated and oracle-based, in order to respond directly to changes in the broader environment.

This is why we are as well requesting the community's feedback, so that this Interest Rate Model could improve Maker's competitive advantage in the DeFi ecosystem.