Bella Lending Whitepaper v0.1

Bella

August 14, 2020

Contents

1 Introduction **1**

2 Deposit **1**

3 Borrow **1**
3.1 Collateral . . . 2
3.2 Liquidation . . . 2

4 Governance **5**
4.1 Reserve . . . 5
4.2 Ballot Strategy . . . 5

5 Contract Architecture **5**

6 Formal Definition **5**
6.1 Basic Concepts . . . 5
6.2 Collateral & Liquidation . . . 7
6.3 Governance . . . 8
6.4 User Account . . . 8

1 Introduction

Bella lending is a protocol that establishes a decentralized cryptocurrency lending market comprised of multiple asset pools, each of which takes one type of currency as the underlying asset. These pools accept deposits from depositors and mint bToken to keep account. On the other side, borrowers can back collateral to borrow from the asset pool. The pool-based strategy enables users to interact directly with the market, rather than with a counterparty. The interest rates of deposits and borrows are derived algorithmically based on market forces.

Compared with prior lending markets like centralized exchanges and peer to peer protocols, the primary benefits of a pool-based decentralized lending protocol are:

- Decentralized trust and governance in a native blockchain manner.
- Accessible to each customer and governed by the community.
- Avoided significant trade cost and friction between counterparties in peer-to-peer protocol.

2 Deposit

The Bella asset pool receives liquidity from depositors. Cryptocurrency put into the asset pool will become a fungible resource, like a drop of water in a pool. The fungible nature offers immediacy and liquidity for the money market. Users can redeem deposits or take out loans as they wish. With the interest rate mechanism introduced below, Liquidity should always be sufficient. Thus, trading with the asset pool should be frirctionless, rather than reliant on other peers or transactions.

Upon deposit, an equivalent amount of ERC-20 tokens called "**bToken**" will be granted to the depositor as a voucher. The bTokens map 1:1 to the underlying assets. Deposits in the Bella market accrue interest over time, which is represented as a growing balance of bTokens. In this way, bTokens hold the same value as the corresponding assets and represent the principal and interest of each transaction.

The **deposit interest rate** of one underlying asset is determined by the corresponding borrow interest rate, which guarantees that depositors and borrowers reach a non-zero-sum wealth, except a portion taken as a reserve (explained in section 4). The definition of each term in the formula can be found in section 6.

$$DepRate = BrwRate \times UtlRatio \times (1 - ResFactor) \tag{1}$$

Depositors can redeem their deposit along with interest by offering the corresponding amount of bTokens. Considering the 1:1 exchange rate, redeeming deposits is quite straightforward if liquidity is fluid enough.

3 Borrow

On the other side, Bella allows users to borrow from the market using bTokens as collateral. Borrowers simply need to specify the desired asset but do not need to match a lending peer. Just as with depositing, borrowing should be instant and smooth as long as there is liquidity. Considering liquidity is determined by the total amount of deposits and borrows, we take the ratio between them as a parameter to dynamically alter interest rates. Also, to incentivize the pool's liquidity, the cost of borrowing and the returns on deposits will rise steeply if cash is close to exhaustion. Therefore, each asset pool has an individual algorithmically derived interest rate that balances the market forces.

The **utilization ratio** that reflects the liquidity and market force is defined as

$$UtlRatio = \begin{cases} 0, & \text{if } TotDep \leq 0 \\ \dfrac{TotBrw}{TotDep}, & \text{if } TotDep > 0 \end{cases} \tag{2}$$

Then, a typical **borrow interest rate** model designed upon utilization ration is shown in figure 1 and equation 3. If the money borrowed is beyond a particular ratio, the interest rate will change to pull it back. Different types of interest models will be deployed to different asset pools according to their own characteristics. And key model parameters (like $BrwRate_0$, $BrwRate_{opt}$, $BrwRate_{ill}$ in this example) can be calibrated through the governance system.

$$BrwRate = \begin{cases} BrwRate_0 + UtlRatio \times \frac{BrwRate_{opt} - BrwRate_0}{UtlRatio_{opt}}, & \text{if } UtlRate \leq UtlRate_{opt} \\ BrwRate_{opt} + (UtlRatio - UtlRatio_{opt}) \times \frac{BrwRate_{ill} - BrwRate_{opt}}{1 - UtlRate_{opt}}, & \text{if } UtlRate > UtlRate_{opt} \end{cases} \tag{3}$$

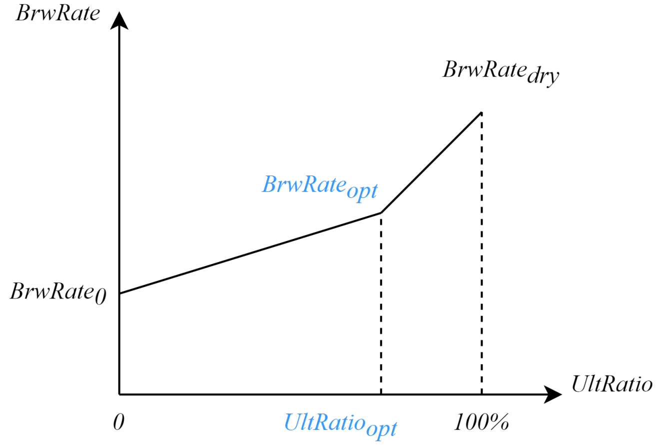

Figure 1: A Typical Borrow Interest Rate Model

Users can call repay action to pay back the borrowed money and the accumulated interest either partially or completely. Then their pledged bTokens will be freed.

3.1 Collateral

To back the borrow position, borrowers must place a greater value of assets as collateral. The collateral is held by Bella market and represented by ownership of bToken. Typically, only low risk, liquid, and high-cap currencies can be configured as collateral. Each collateral asset has an individual **loan-to-value** defining the maximum value of cash that can be borrowed upon a specific amount of this collateral. The basic idea behind LTV is hedging against risks brought by price fluctuation. Generally, illiquid, small-cap assets have low LTV, while liquid, high-cap assets have high LTV.

$$LTV = \frac{\text{Maximum Value to Borrow}}{\text{Collateral Value}} \tag{4}$$

A user may interact with several different asset pools. The sum of its underlying asset balances, multiplied by the corresponding LTV is the **borrowing capacity** of this account. Any action that possibly raises borrowed asset or lowers borrowing capacity should be meticulously checked before executed.

3.2 Liquidation

However, price fluctuations always occur in the world of cryptocurrency. When the price of the collateral drops below a certain portion of the value of borrows, a liquidation event occurs. Liquidation incentives arbitrageurs to close an under-collateralized position by offering **liquidation bonuses**. The largest portion of borrows in collateral that keeps the borrower collateralized is called **liquidation threshold**. During the liquidation process, the **close factor** will prevent the liquidator from taking away all the collateral of the borrower. It is defined as the maximum fraction of the original loan that can be liquidated.

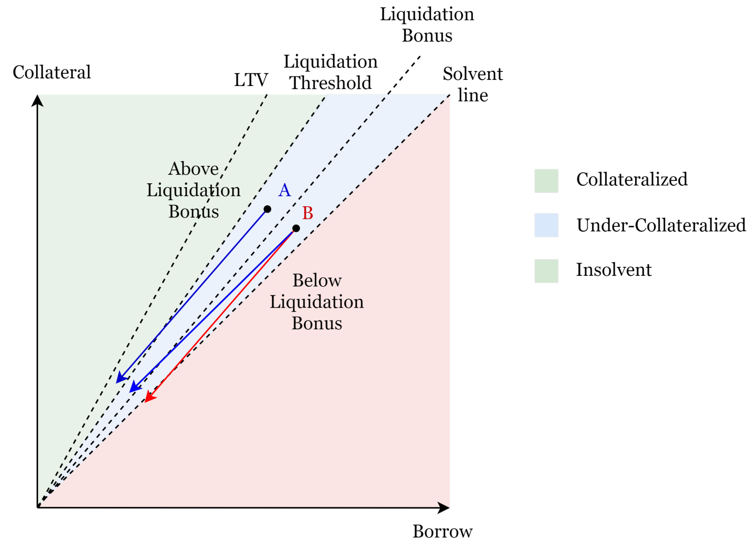

Figure 2: Liquidation Strategy Explained

Following the same approach as for the LTV, Each collateral asset has an individual liquidation threshold, close factor, and liquidation bonus. It is obvious that the liquidation threshold should be larger than the LTV, which reduces the risk of bringing a user to under-collateralized status. A typical example of the relationship among these parameters and liquidation mechanism is shown as figure 2. The point is to increase the liquidity of borrowers and reduce the risk of insolvency. However, liquidation bonuses may bring the incentives reversely and push borrowers towards illiquidity[2].

$$LiqTh = \frac{\text{Maximum Borrow to be Collateralized}}{\text{Collateral Value}} \tag{5}$$

Without loss of generality, Let us define the shown liquidation model as that LTV is 70%, $LiqTh$ is 85%, $LiqBonus$ is 5%. Then the three lines respectively represent these three parameters with their slopes as $1/70\% = 1.43$, $1/85\% = 1.18$, $1 + 5\% = 1.05$. The fourth line, called the solvent line has a slope of one. This means the amount borrowed is equal to the collateral put up by the borrower. Then the areas between different lines can help to understand the practical significance of liquidation parameters.

- Green area: Collaterlized account. User has no need to provide more collateral.
- Blue area: Under-collateralized account. User needs to provide more collateral to back their borrows, arbitrageurs can step in to bring liquidity and get bonus.
- Red area: Insolvent account. User has more debt than collateral and no incentive to repay borrow.
- Between LTV and Liquidaiton Threshold: User stays in collateralized status but is not allowed to borrow more. Users in this area should pay attention to the possibility of becoming under-collateralized. This is a buffer area for price fluctuation.
- Between Liquidation Threshold and Liquidation Bonus: Account A has triggered a liquidation event and someone comes to repay the debt to gain 1.05 times return. This is indicated as point A moves along the blue line towards the left-bottom part. The blue line is parallel with liquidation bonus line with slope 1.05. It can be observed that the user will be liquidated at the end of the day.
- Between Liquidation Bonus and Solvent Line: Account B has undergone a sharp price drop of collateral and failed to be liquidated in time. It moves to the current location in the coordinate, then a 5% liquidation

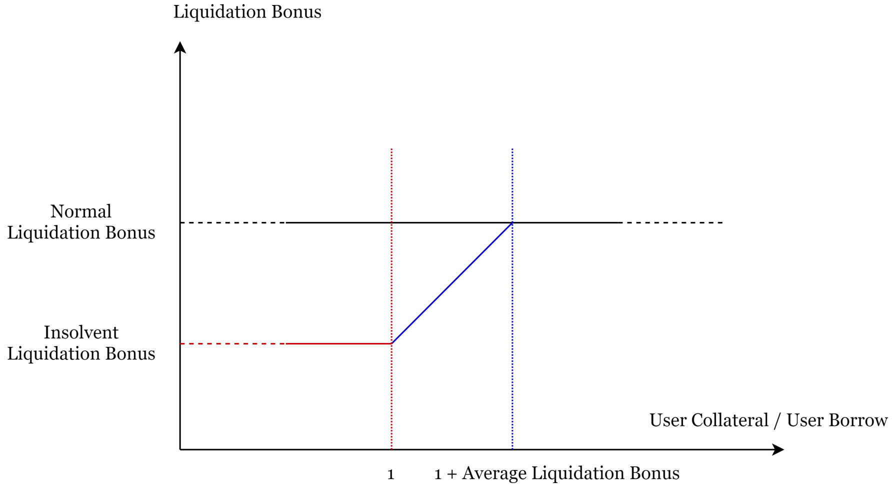

Figure 3: Dynamic Liquidation Bonus Example

bonus moves the point along the red line with a slope of 1.05. Unfortunately, borrowers below the line are pushed towards insovlent area. This is the situation we mentioned before that static liquidation bonus will be agianst the orignial intension.

We propose a dynamic liquidation bonus related to account status for those approaching insolvency. Each account has a real-time **user liquidation threshold** calculated as the weighted average of different liquidation thresholds of its collaterals, where the weight for each threshold is the collateral balance. The **health factor** of the account, which represents its health degree, can be derived from its user liquidation threshold.

$$HlthFactor = \frac{UserCol \times UserLiqTh}{UserBrw} \tag{6}$$

When the health factor of one account drops below 1, it is considered under-collateralized and triggers a liquidation event. Arbitrageurs are incentivized by the liquidation bonus to step in. At the very beginning, the additional reward is set as the normal liquidation bonus. It the account's health worsens due to a sharp drop of collateral value or network congestion, the bonus given to liquidators will decrease when the collateral to borrow ratio of this user breaks a specific line. Also, the close factor limit will be removed to encourage a thorough liquidation. The specific line here is called **global liquidation bonus**, which is a weighted average of each asset pool liquidation bonus. This parameter represents the general bonus level of the entire market. Once the account health factor drops below this threshold, the commonly used liquidation will make it more illiquid. The proposed dynamic liquidation bonus mechanism will mitigate this problem. It can be described piecewise as

$$LiqBonus = \begin{cases} NormLiqBonus, & \text{if } \frac{UserCol}{UserBrw} \geq 1 + GlobLiqBonus \\ \frac{\frac{UserCol}{UserBrw} - 1}{GlobLiqBonus} \cdot LiqBonusDiff + InslLiqBonus, & \text{if } 1 \leq \frac{UserCol}{UserBrw} < 1 + GlobLiqBonus \\ InslLiqBonus, & \text{if } \frac{UserCol}{UserBrw} < 1 \end{cases} \tag{7}$$

where $LiqBonusDiff = NormLiqBonus - InslLiqBonus$.

4 Governance

Bella will launch with a centralized administrator who will take full control and responsibility of the market at first. After a run-in period of parameter calibration and protocol improvement, it will be transited to a community operated DAO to decentralize the governance. At that time, the protocol is governed by the BELLA token and any improvement proposal should be voted by the stakeholders to be approved.

The typical policies that the governance system has control over include:

- The Listing or de-listing a new asset pool of a specific underlying asset.
- Changing the interest rate model, liquidation bonus model per pool.
- Changing the liquidation threshold, LTV, liquidation bonus, close factor per pool.
- Withdrawing the reserve of a bToken.
- Adjusting or changing the governance system. The governance method will evolve over time according to the decisions of community.

4.1 Reserve

To mitigate the risk caused by contract flaws, liquidation failure, or market changes, the reserve collects transaction fee from interests and handles problems according to polices agreed on by stakeholders. There are several possible things that may cause market deficit. The governance system can deploy a strategy to remedy uncollectibles by reserve.

4.2 Ballot Strategy

When the governance system switches to a completely decentralized community governance model, the community will approve or deny policy proposals by vote. Within the context of the community, any proposal can be treated as a public good. Everyone "consumes" the results of the same decision, they just have different opinions about how much they like the result. The ballot strategy deployed here should balance the opinions from two groups of people. the majority who care the proposal a little and the minority who care a lot.

The typical ballot strategy used in decentralized finance governance systems is one token one vote; this will give the owner of a large amount of BELLA too much power in the proposal approval process. On the other hand, one account one vote will lead to the desires of the minority being ignored. Bella will use quadratic voting or some analogous voting model as the community ballot strategy, which is a trade-off between two mentioned choices. This may not be the best option in all situation, but it can also be altered or replaced by governance as well.

Quadratic voting proposed that the n^{th} ticket is worthy of n tokens as shown in figure 4[1]. The quadratic means that the total tokens needed for n tickets is proportional to n^2. This voting model limits the ability of "wealthy" accounts although they may bypass through distributing their tokens to multiple addresses. The friction introduced here will certainly influence the ballot process. If some issues occur in run-time, governance may alter the factor $alpha$ in Ticket Price = Ticket Index$^\alpha$ to transform quadratic voting into one token one vote or some varieties with stricter restriction.

5 Contract Architecture

6 Formal Definition

6.1 Basic Concepts

- **Total Deposit**, $TotDep$, Total amount of deposit in the asset pool. The effective number of bits is the same as that of underlying asset, typically 18 decimal digits.

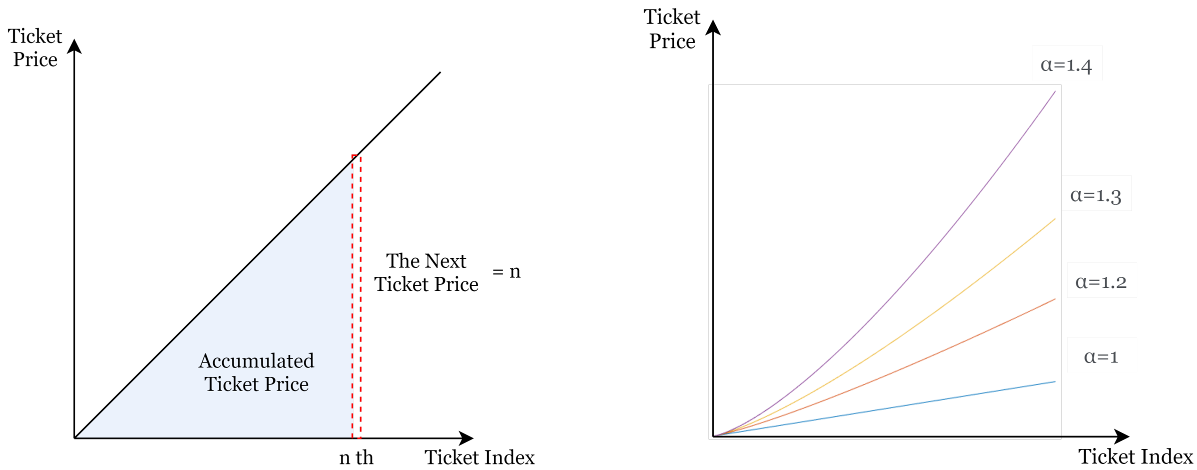

Figure 4: Quadratic Voting and Quasi-Quadratic Voting Model

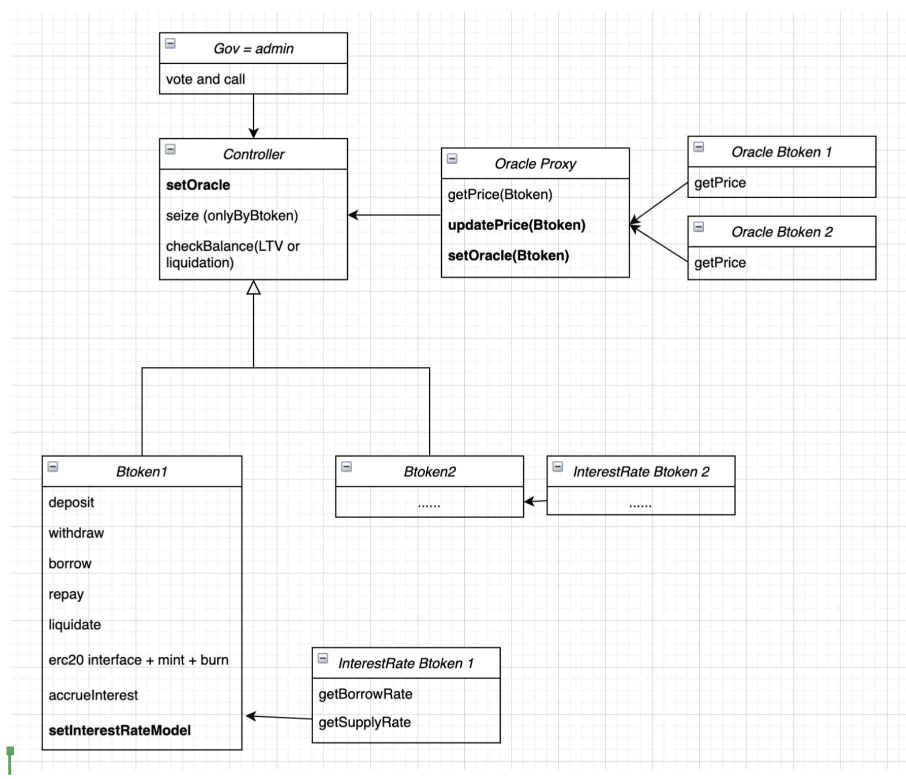

Figure 5: Bella Contract Architecture

- **Total Borrows**, $TotBrw$, Total amount of borrow in the asset pool. The effective number of bits is the same as that of underlying asset, typically 18 decimal digits.
- **Utilization Ratio**, $UtlRatio$, Total borrows as a percentage of total deposit.

$$UtlRatio = \begin{cases} 0, & \text{if } TotDep \leq 0 \\ \dfrac{TotBrw}{TotDep}, & \text{if } TotDep > 0 \end{cases}$$

- **Optimal Utilizaiotn Ratio***[1], $UtlRatio_{opt}$, The utilization ratio target set by interest rate model, beyond the interest rate rises sharply.
- **Borrow Interest Rate**, $BrwRate$, The cost of borrowing, float to keep the balance of utilization and liquidity of the asset. The specific rate is influenced by utilization ratio, expressed in annual percentage rate.
  - Starting Borrow Interest Rate*, $BrwRate_0$, The borrow interest rate at no utilization
  - Optimal Borrow Interest Rate*, $BrwRate_{opt}$, The borrow interest rate at optimal utilization ratio
  - Illiquidity Borrow Interest Rate*, $BrwRate_{ill}$, The borrow interest rate at full utilization

$$BrwRate = \begin{cases} BrwRate_0 + UtlRatio \times \dfrac{BrwRate_{opt} - BrwRate_0}{UtlRatio_{opt}}, & \text{if } UtlRate \leq UtlRate_{opt} \\ BrwRate_{opt} + (UtlRatio - UtlRatio_{opt}) \times \dfrac{BrwRate_{ill} - BrwRate_{opt}}{1 - UtlRate_{opt}}, & \text{if } UtlRate > UtlRate_{opt} \end{cases}$$

- **Deposit Interest Rate**, $DepRate$, Incentives to deposit currency, float depending on the liquidity of pool at a certain time, expressed in annual percentage rate.

$$DepRate = BrwRate \times UtlRatio \times (1 - ResFactor)$$

6.2 Collateral & Liquidation

- **Loan-to-Value***, LTV, The maximum value that can be borrowed with respect to collateral backed.
- **Close Factor***, $ClFactor$, The maximum fraction of the original borrow that can be liquidated.
- **Liquidation Threshold***, $LiqTh$, Maximum borrow to collateral ratio to remain in collateralized status, typically smaller than Loan-to-Value.
- **Liquidation Bonus***, $LiqBonus$, An additional part of collateral as bonus for liquidator, expressed in the percentage (of repaid collateral).
  - Normal Liquidation Bonus*, $NormLiqBonus$, The liquidation bonus set for nearly collateralized accounts
  - Insolvent Liquidation Bonus*, $InslLiqBonus$, The liquidation bonus set for nearly insolvent accounts

$$LiqBonus = \begin{cases} NormLiqBonus, \quad \text{if } \dfrac{UserCol}{UserBrw} \geq 1 + GlobLiqBonus \\ \dfrac{\frac{UserCol}{UserBrw} - 1}{GlobLiqBonus} \cdot LiqBonusDiff + InslLiqBonus, \quad \text{if } 1 \leq \dfrac{UserCol}{UserBrw} < 1 + GlobLiqBonus \\ InslLiqBonus, \quad \text{if } \dfrac{UserCol}{UserBrw} < 1 \end{cases}$$

where $LiqBonusDiff = NormLiqBonus - InslLiqBonus$

[1] The parameter labeled with * means it is a protocol argument, which can be modified by governance system.

- **Global Liquidation Bonus***, $GlobLiqBonus$, A weighted average of the liquidation bonus of each asset pool in the market, represents the threshold that defines an account as nearly insolvency.

$$GlobLiqBonus = \sum_i \text{Pool } TotBrw\% \times \text{Pool } LiqBonus$$

6.3 Governance

- **Total Reserve**, $TotRes$, Total amount of reserve in the asset pool. The effective number of bits is the same as that of underlying asset.
- **Reserve Factor***, $ResFactor$, A proportion of borrow interest rate is retained as reserve.

6.4 User Account

- **User Borrow**, $UserBrw$, Total amount of borrow in the user account.
- **User Collateral**, $UserCol$, Total amount of collateral in the user account.
- **Borrowing Capacity**, $BrwCpty$, The maximum value that one user can borrow from the asset pool based on his collateral.

$$BrwCpty = \sum_i UserCol\% \times \text{Collateral } LTV$$

- **User Liquidation Threshold**, $UserLiqTh$,

$$UserLiqTh = \sum_i UserCol\% \times \text{Collateral } LiqTh$$

- **Health Factor**, $HlthFactor$, The health degree of one user.

$$HlthFactor = \frac{UserCol \times UserLiqTh}{UserBrw}$$

References

[1] Vitalik Buterin. Quadratic payments: A primer. Website, 2019-12-7. `https://vitalik.ca/general/2019/12/07/quadratic.html`.

[2] Openzeppelin Security. Compound audit. Website, 2019-08-23. `https://blog.openzeppelin.com/compound-audit/`.