Debita: A Credit Market for DeFi

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Abstract

We introduce Debita Protocol, an efficient decentralized credit market, and contrive its own native yield bearing stablecoin, DS. Debita as an uncollateralized lending protocol introduces credit default swaps markets to bootstrap extra liquidity, provide insurance to the lenders, and estimate probability of default. Debita's credit default swaps (dbCDS) also allows issuance of the fully collateralized stablecoin DS, by combining and hedging the volatility of the underlying bond with dbCDS. Effectively, the lending process reduces to an act of minting or buying DS, where interest paid by the borrowers are directed to DS holders and dbCDS sellers. Our design allows DS to circumvent the well known dilemma of capital efficiency and safety of stablecoins; it is designed to be as much, if not more, as scalable as fiat-backed and algorithmic stablecoins while inheriting the merits of over-collateralized models.

1 Introduction

While much of DeFi's success has been built on overcollateralized lending, it is without dispute that uncollateralized lending has a much larger addressable market, yet is relatively untouched in DeFi. Existing uncollateralized lending protocols are highly centralized, and while it is commonly regarded that decentralization comes at the expense of efficiency, we present a opposing view and a platform design that is contrary to the premise. We believe existing systems are prone to certain risks, and does not make the most of DeFi's potiential. We first define the following risks associated with a centralized uncollateralized lending platform, and propose Debita Protocol, where its novel design serves to mitigate the revealed risks.

a) Credit Assessment risk Undercollateralized loans, sometimes referred to as unsecured loans or signature loans, are loans that are approved without the use of property or other assets as collateral. Instead, the terms of these loans are most often contingent with the borrower's credit worthiness. Typically, borrowers must clear a certain threshold of credit score to secure undercollateralized loans. These ratings are usually determined by centralized entities such as StandardPoor's or Moody's for corporate bonds and major credit bureaus for individual loans. It is trivial to see that this system introduces a central node of failure, primarily due to inefficiencies associated with incentive misalignment, as there isn't a clear relationship between the risk *assessors* and risk *bearers*.

b) Default Risk Existing attempts at establishing a blockchain powered credit market, however, fails to correctly assess and manage credit risk associated with a debt-credit relation. A naive pool-based borrower-lender relationship could be established without any considerations for a credit event, in which case would result in the lenders losing their funds. Inspired by financial products in traditional markets, Debita protocol resolves this by introducing a derivative product akin to credit default swaps (CDS), funded by an exogenous insurance pool. Anyone could take a directional position in this DebitaCDS (dbCDS), where buyers would be insured against risk of a default of the reference entity by the sellers. In addition to providing credit risk hedging opportunity for the lenders, this funnels extra source of speculative liquidity into the protocol, which increases expected revenues for all parties in the system.

c) Liquidity Risk Consequently, the utilization of dbCDS in the lending process provides the necessary building block for Debita's principal product – its own native stablecoin. Typically, liquidity suppliers in a lending pool are associated with liquidity risk. Existing protocols aim to remedy this by supplying them with xTokens, which are not considered general assets. In Debita, lenders are essentially provided with two intangible assets, a) an yielding bond and b) dbCDS. A straightforward observation is that since an asset solely backed by debt will be fully exposed to credit risk of the reference entity, a product that combines it with an equivalent notional value of dbCDS will be fully hedged against the underlying default risk. Such product should maintain its stability in terms of value at any given point even if the market prices the debt lower than its face value. Debita's stablecoin, DS, will serve this purpose; it aims to be an interest bearing liquid asset that is returned to lenders, where its value will remain pegged to 1 US dollar.

In light of these problems, we aim to create a novel crypto-native credit market that abides to the ethos of decentralization and free market principles. Debita protocol will address the aforementioned shortcomings of traditional and existing decentralized credit markets. Its primary contribution is as follows: an efficient decentralized credit market that allows tokenization of volatility-muted bonds that serves to dramatically increase the efficiency and composability of existing uncollateralized lending platforms.

2 Debita Protocol

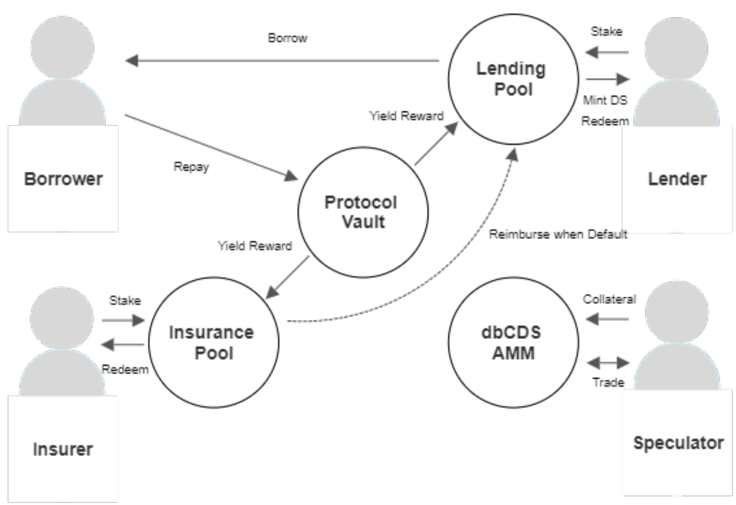

Figure 1: Conceptual illustration of Debita Protocol

In this section, we present a general outline of the mechanism of Debita Protocol. There are 4 entities that is necessitated by the system; lenders, borrowers, insurance providers (insurers), and speculators.

2.1 Basic Outline

Below we present a very high level description of the lending process.

- Lenders will act as primary *liquidity suppliers* and deposit value into a LendingPool contract, which encompasses a notion of *reserve.* In return, they will mint and receive DS stablecoins. Lenders can redeem their DS in exchange for their collateral in the protocol, of which the returned DS will be burned.

- Aspiring borrowers, each indexed by $i, i = 1...N$, will go through a credit assessment process and when permitted, will be granted access to the principal amount of debt from the reserve.

- Insurance providers(insurers) are secondary liquidity suppliers and will deposit funds into the InsurancePool contract. In return, they are granted permission to mint $dbCDS_i$, where i indexes each borrower. Funds in InsurancePool and minted $dbCDS_i$ will be paired to provide liquidity for dbCDS to be trade-able in an AMM.

- Exogenous speculators and lenders will be able to place directional bets on $dbCDS_i$ for all $i \in N$, after which its price will contribute to determining the credit-worthiness of the borrowers and quoted interest rates. Governance voting system by insurers and lenders will determine the final elligibility of the loan.
- Borrowers will periodically repay a portion of the principal amount in addition to interest. Interest generated by borrowed capital will be periodically distributed to lenders and insurers, where the ratio would be determined by an auction process.
- Upon a credit event, funds that amounts to a predetermined fraction of the principal value of defaulted borrower will be directed from the InsurancePool to LendingPool, and the collateral of dbCDS sellers will be collected by dbCDS buyers.

These steps are to be executed asynchronously, such that for any given time t, there will be a constant flow of liquidity both inwards and outwards. Total liquidity supplied will be $L_T = L_l + L_i$, where L_l and L_i denotes the supply of lenders and insurers respectively.

2.2 Examples

Here we provide some tangible examples of the mechanisms of Debita Protocol

- Alice has 100k USD, and wants it to generate yield. She could a) buy DS from the open market or b) mint DS by supplying 100k USD as collateral, and stake it on Debita. She will receive dDS tokens where she could redeem it for DS anytime she wishes. She could then optionally go to a money market and borrow against her dDS tokens to mint/buy more DS to earn leveraged yield, which would then increase the total value stored in Debita's lending pool avaiable for lending.
- Bob has 100k USD, and is a bit more risk tolerant then Alice. He deposits and locks up his funds in the insurance pool to earn higher yield than Alice, and how higher would be determined by the ratio of funds in insurance pool to funds in the lending pool. However, when there is a credit event, Bob will lose a portion of his funds, in proportion to the total amount lost divided by the value locked in insurance pool.

2.3 DS

Decentralized stablecoins can be generally classified into two categories; algorithmic and overcollateralized. Member of these categories trades off capital efficiency for liquidity risk. As algorithmic stablecoins are designed to swiftly adjust its circulating supply based on changes in its demand using seigniorage shares, its growth is deemed more reflexive. However, its uncollateralized nature makes it susceptible for panic based capital flight, also termed as a bank-run. As a bank run progress, it generates its own momentum; as more people try to withdraw, the likelihood of creating bad debt increases, triggering further withdrawals. On the other hand, growth of overcollateralized stablecoins is burdened by its necessity of constant borrowing demand from collateral providers when minting new stablecoins. For periods where borrowing demand is low, this capital inefficient structure makes it such that its demand would outpace the supply, impeding its growth.
We search in the design space of *overcollateralized* stablecoins that inherits the safety of full collateralization and would simultaneously enjoy the capital efficiency and scalability of its algorithmic counterparts. This is the thesis we had in mind when designing DS.

- How is DS overcollateralized?
  A user is required to deposit a dollar worth of value for every DS minted. In addition, this deposit is backed by an external insurance fund. Although the lenders are minting with a $1:1$ exchange rate, as a system DS would be supplied with a $1:1+x$ exchange rate, where $0 \leq x \leq 1$ would be the ratio of funds in insurance funds over funds in lending pools. A user is always able to redeem a dollar worth of value for every DS.

- How is DS capital efficient?
  i) Dollar deposited by the minters(lenders) would not be rested collateral and instead is utilised by the borrowers.
  ii) Demand for DS would not only stem from demand for collateralized loans, but also from a pursuit of yield. Reflexivitiy is contrived as increased demand for DS would elicit an increased demand for uncollateralized credit-backed loans, as more funds supplied induces a lower interest rate.
  iii)Additional collateral from insurance funds are not rent seeking "resting money" as they are also used to collect premiums from dbCDS speculators.

2.4 DSS

DSS is a value accrual token for Debita Protocol. It serves these main purposes; as a token which value coincides with the growth of DS and Debita, as a debt token that absorb liquidity crunches, as extra layer of insurance during credit events, and lastly as a governance token. For every minted DS, a fraction of the value supplied by LPs will be used to burn DSS, where that fraction is the dynamically adjusted *collateral ratio* of Debita.

3 Borrowing and Lending

3.1 Borrowers and Lenders

Lenders: Lenders can be anyone with liquidity to supply and a liking for yield. They will be the *primary* liquidity suppliers in Debita in the sense that most of L_t would be composed of L_l. From the lenders perspective, the most basic functionalities of Debita would generate an experience that would not be much different from minting and redeeming stablecoins in an alternative stablecoin protocol, except that interest rate for minting would be negative, as DS is yield bearing. This adds an extra dimension for organic demand source for DS compared to other stablecoins, while providing an additional variable for optimizing peg stability, as will be outlined later.

When minting DS, lenders will deposit stablecoins to the *LendingPool* contract. Minting a dollar worth of DS requires placing a dollar worth of value into the system, by depositing the appropriate ratio of stablecoin and DSS, where the supplied DSS will be burned. Lenders can withdraw their supplied money by either selling DS in the open market or redeeming from Debita.

Borrowers: Borrowers could be any institutions, protocol or smart contract in demand for liquidity. Primary driver for demand could be as simple as necessity for liquidity to bootstrap the early stages of the protocol(akin to services provided by LAAS protocols), or could range to market makers and arbitrageurs in need for extra leverage. Borrowers will submit facts that will be factored in determining the creditworthiness, such as motive, balance sheet, recent profitability, liquidity risk, track record of the team, etc. Details on credit assessment of borrowers is outlined in the next subsection. Once debt is issued, borrowers will be required to repay at regular intervals.

3.2 Insurers

Insurers are individuals who want to collect yields but with a higher risk appetite than lenders. They will generate yield from two sources: a) a portion of interest rates paid by borrowers, as minting DS abstracts away purchasing dbCDS b) premium collection from dbCDS speculators. As probability of default of all borrowers at any given point is low, they will be able to leverage their capital by backing more debt than their total capital. This *leverage ratio* $\alpha = \frac{TotalInsurerfunds}{TotalDebt}$, where $0 \leq \alpha \leq 1$ determines the capital efficiency of the system. When $\alpha = 1$, all debt is fully backed, and lenders cannot lose money from defaults. This also implies that DS is *deterministically* fully backed when $\alpha = 1$. In the other extreme when $\alpha = 0$, no debt is backed, and lenders will be fully exposed to credit risk. With higher α, there is less risk for stablecoin holders but it takes more dollars to mint each additional DS, restricting its growth. α would be determined by the market; how much deposits are made by the insurers at any given point. If the market deems that risk adjusted yield for backing debt is attractive, there will be more insurers and consequently higher α, vice versa.

3.2.1 Handling Defaults

When a borrower defaults, the lowest level tranche responsible for covering bad debt would be funds from insurers. If the total locked deposits insurers funds is larger than the default principal value than funds equal to the default amount will be slashed from the InsurancePool and directed to the LendingPool, which will keep DS fully collateralized.

3.3 Credit Assessment: Markets Aggregate Opinions

As a decentralized protocol the goal of Debita is to a)democratize the rating system and b)promote a fair credit assessment protocol such that incentives of the credit risk *bearers* and *assessors* are alligned, if not completely equal. As such, the credit assessment process will consist of the following procedures

a) Aspiring borrower i has to submit a proposal with relevant details that adds weight to the creditworthiness of the debt, This includes but is not limited to factors contributing in analyzing asset coverage, structural considerations and modeling recovery scenarios

b) This proposal is made public, after which speculators and lenders are able to take either a *long* or *short* position in $dbCDS_i$ in an AMM. In effect, anyone can sell or buy insurance.

c) Debita models the AMM as a binary options market, where we follow previous work and interpret the price of $dbCDS_i$ as the participants' mean estimate of the probability of default of i. We denote this probability estimate P_{mi}. We then weigh this probability estimate with the empirical probability P_{ei} inferred from previous data. Debita's governance voting system, comprised of lenders, insurers, and DSS holders will then go through a vote on the creditworthiness of borrower i where its poll results will finalize the loan approval

In contrast to centralized credit rating systems, it is clear that incentives are completely aligned. All raters, including voters and speculators, are financially motivated with their funds are in stake. Quality and quantity of information entrenched in the dbCDS market will be a function of market efficiency, which again relies on liquidity and number of market participants, and we expect this to grow along with the protocol.

3.3.1 Price as Probability of Default

Wolfers and Zitzewitz (2004) summarize a variety of field evidence across several domains suggesting that prediction market prices appear to be quite accurate predictors of probabilities. We are then interested in how to interpret the price of $dbCDS_i$ as probability of default of company i. As with all credit markets, accurate default probability estimate is invaluable for assessing/managing risk and quoting interest rates. We thus consider a simple prediction market in which traders can long and short an all-or-nothing contract (a binary option) paying 1 unit if a credit event occurs, and 0 otherwise. Adapting previous work(cite), we state the following observation

Observation 1: *As number of market participants increases, the resulting* ***price*** *of* $dbCDS_i$ *converges to the (capital weighted)* ***average estimated probability of default*** *of all available speculators*

Proof: Let $f(Pr_i, C)$ be the joint distribution of traders' estimate of the probability of default of company i, and their initial capital. Then $Pr_{ij}, C_j \sim f(Pr_i, C)$ would represent a sample trader j's belief on i and her starting wealth. Denote n_j the number of contracts bought by j and p_i the price of the contract.
We assume that each trader is maximising her expected log-returns

$$\mathbb{E}[R_{ij}] = Pr_{ij} \log(C_j + n_j(1 - p_i)) + (1 - Pr_{ij}) \log(C_j - n_j p_i)$$

taking the derivative and optimizing w.r.t n_j, we have that $n_j^* = C_j \frac{Pr_{ij} - p_i}{p_i(1-p_i)}$.
Using the equilibrium criterion for markets and solving for p_i,

$$demand = \sum_{j \in t} C_j \frac{Pr_{ij} - p_i}{p_i(1 - p_i)} = \sum_{j \in t'} C_j \frac{-Pr_{ij} + p_i}{p_i(1 - p_i)} = supply$$

we have that

$$p_i = \sum_{j \in (t \bigcup t')} \frac{C_j}{\hat{C}} Pr_{ij}$$

where $\hat{C}$ is the average capital of all participating traders. Then by the law of large numbers,

$$\lim_{|t \bigcup t'|->\infty} p_i = \mathbb{E}[\frac{C}{\hat{C}} Pr_i]$$

Thus, we have that the price of *dbCDS* is an unbiased estimate of the *mean probability estimate* of all traders.

Implications: The derivation of n_j^* states that a rational trader would take position only if her own probability estimate differs from the price of $dbCDS_i$. This gives a simple valuation heuristic for average traders in *dbCDS* markets. For example, Debita could inform the traders to take a *long* position if they think the probability of default is greater than the price, and take a *short* position otherwise.

Note that p_i is that the average probability estimate that is weighted over all participating market participants, the weights being their initial capital relative to the mean. An attractive interpretation is that that the aggregate probability will give more weight to the traders with greater wealth, which is an intuitively reasonable argument as more capitalized traders are usually relatively better informed than their counterparts.

In this model, there is heterogeneity in the beliefs among traders. Informally, as individual beliefs may reflect private but noisy information on the likelihood that the event might occur, the prediction market aggregates and averages out the noise. If the noise term is normally distributed, it follows that the prediction market price, in the limit of more market participants, becomes an ever more accurate estimate of the likelihood of the event occurring, as stochasticity follows an inverse relationship with the amount of information.

3.3.2 Scalability

Indeed, in an efficient market the price of an binary option style dbCDS will yield decent probability estimates of default. However, the above derivation entails two assumptions; no liquidity limitation(when enforcing supply and demand equilibrium constraints) and large number of market participants. To mitigate these risks, Debita would have to provide a trading experience that is accessible and intuitive with ample liquidity across all price ranges.

As the underwriting process expands and Debita brings in smaller borrowers, creating a market for each individual entity is not scalable. In such case, Debita will cluster the borrowers with identified features commonly used to assess credit, and let speculators bet on an aggregated market for each cluster.

3.4 Comparisons To Existing Credit Markets in DeFi

Here we outline some of the factors, from the perspectives of each parties, why Debita would be preferred over existing undercollateralized lending protocols or Liquidity as a Service protocols, for each parties.

Lenders/Liquidity Suppliers:

- Liquidity Risk: Lenders who fund loans in Debita do not have to lock up their assets for the duration of the loan. As lenders are supplied with stablecoins in return of their deposits, they are provided the option to preserve their state of liquidity. In addition, redeeming for their collateral is much akin to the redeeming process in any stablecoin protocol, as our incorporation of a seigniorage debt token would ensure that lenders would be able to freely redeem their assets for equal value.

- Easier lending process: For liquidity suppliers, most of the lending process is abstracted to the act of simply purchasing DS in the open market, where arbitrageurs would instead deposit funds into *LendingPool* instead.

- Customized Yield: Debita's lending process provide the basis for enhanced composability. Lenders will be able to invest into products that is tailored to each risk profiles. For example, an individual with a high risk tolerance could maximise her yield by looping the process of minting DS by borrowing against DS in money markets, and using DS minted on the last loop to short dbCDS. Alternatively, she could long dbCDS to hedge against depeg risk(default risk of borrowers) of DS.

- Better guaranteed insurance: As Debita invites an exogenous liquidity source through a separate insurance funds, which is also additionally funded by dbCDS premiums, lenders will be more safe in a credit event.
- Hedging credit risk: In existing uncollateralized lending protocols, lenders have to forfeit their rights to determine the borrower's creditworthiness to pool delegates, and are left no choice either but to withdraw if they disagree. Debita alllows lenders to purchase dbCDS if they deem the credit should be valued lower than the market and the voters.

Borrowers

- Competitive Interest rates: As alluded above, Debita incentivizes more supply of liquidity from lenders, which promotes better rates for the borrowers.
- Intuitive loans: Existing LAAS are difficult to navigate and the some of the implications might be nuanced, which might lead to unexpected complications. Borrowing liquidity from Debita, however, is as simple as getting approved and paying interest.

System

- Democratized Credit Rating: Through dbCDS market, creditworthniess will be take into account aggregated information of the mass. It is reasonable to assume that information quantity is a function of number of deciders. A naive decentralized solution to a centralized credit scoring system would be DAO governance, which significantly decreases efficiency, whereas our system is an elegant approach that easily scales and abides to the DeFi ethos.
- Better Composability: With an asset that is simultaneously backed by debt and insurance, users can utilize the money legos in DeFi to generate more yield opportunities.

3.5 Quoted Interest Rates

Let us denote the returns from lending to the reference entity i as R_i. As payments from borrowers are probabilistic by nature, we are rather concerned with expected payments $\mathbb{E}[R_i]$. It should be noted that $\mathbb{E}[R_i]$ is normally a variable that is given by the utilization rates of the pool, and we are interested in finding how much risk adjusted interest rate should be quoted by the protocol.

Given the probability of default of entity i before maturity is P_i and its recovery rate after default event M_i we can derive the expected return of the *total system* from issuance until maturity as a function of *Quoted Interest* I_i

$$\mathbb{E}[R_i]_{I_i} = (1 - P_i)I_i - P_i M_i$$

simply rearranging gives us the risk adjusted interest rates that needs to be quoted,

$$I_i = \frac{\mathbb{E}[R_i]_{I_i} + P_i M_i}{1 - P_i}$$

Note that this is *system-wide* expected return. We can further decompose it to the respective elements lenders' and insurers' expected returns. Under the assumption that the insurers funds is the lower level tranche and is primarily utilized to fill up LendingPool during a credit event, the system's expected return can be decomposed as follows

$$\mathbb{E}[R_i]_{I_i} = \mathbb{E}[R_L]_{I_i} + \mathbb{E}[R_T]_{I_i}$$

where

$$\mathbb{E}[R_L]_{I_i} = (1 - P_i)(I - I_b) - P_i(\mathbb{1}(c \in C))M_i$$

$$\mathbb{E}[R_b]_{I_i} = (1 - P_i)I_b - P_i(\mathbb{1}(c \notin C))M_i$$

C denotes the set of events where insurers are bankrupt. This occurs when the total amount of recovery rate weighted defaults exceeds the funds in InsurancePool contract. Under this event, any additional defaults would be deducted from the LenderPool contract.

We also define leverage ratio of insurers $\alpha := \frac{N\hat{a}}{\hat{b}}$, where $\hat{a}, \hat{b}$ denotes the average principal amount for all borrowers $i = 1...N$ and total funds deposited by insurers, respectively. We are then ready to state the following observation:

Observation 2 *Given a constant desired $\mathbb{E}[R_L]_{I_i}$ for a company i, there is an inverse relationship between the leverage ratio α and quoted ratio I_i.*

Proof:

$$\mathbb{E}[\mathbb{1}(c \in C)] = P(c \in C)$$
$$= P(n = |\hat{e}| \ \& \ \sum_{i \in \hat{e}} Pv_i \geq \hat{b})$$

$$\leq P(n = |\tilde{e}|)P(\sum_{i \in \hat{e}} pv_i \geq \hat{b}|\hat{e})$$
$$\leq P(n = |\tilde{e}|)P(\sum_{i \in \hat{\hat{e}}} pv_i \geq \hat{b})$$

Noticing that the first probability follows a poisson binomial distribution,

$$= \sum_{A \in F_k} \prod_{j \in A} P_j \prod_{\hat{j} \notin A} (1 - P_i) P(\sum_{i \in \hat{\hat{e}}} pv_i \geq \hat{b})$$

Where $\hat{e}$ is the set of all reference entities that has declared default between issuance of debt until i's maturity, and $\tilde{e}$ denotes the set of entities that declares default between issuance of their entity. $\hat{\hat{e}}$ denotes the set of entities that is indebted the $\hat{e}|$ largest principal. These subtle difference relaxes the assumption of a shorter timespan until default, hence the inequality. n denotes the random variable that represents the number of defaults out of N entities. Taking the expectations on both sides on equation 5, we have our results.

Implications What observation 1 states is quite intuitive, less insurance funds compared to total amount borrowed requires a greater amount of interest rate quoted by the lenders, as they have less guarantees their funds will remain safe in credit events. What merits attention is the sensitivity to the number of lenders, as F_k has $\frac{n!}{(n-k)!k!}$ elements, quoted interest rates needs to be drastically increased with a marginal increase in insurers leverage.

4 DS, a stablecoin

4.1 Minting DS

Minting DS is meant to be a similar experience as minting any other collateralized stablecoins. Users should deposit 1 dollar worth of an external stablecoin to mint 1 dollar worth of DS. This value will be directed to the *LendingPool*.

4.2 Redeeming DS, Bankrun risk assessment

We believe redeem-ability is of utmost importance when maintaining the dollar-peg of a stablecoin. Users need to seamlessly be able to and most pertinently believe that they could redeem a dollar worth of value for every DS minted. However, as deposited funds will be lent to borrowers, redeemers faces the risk of liquidity crunch during periods where high demand for liquid asset coincides with periods of high utilization rate of the deposited funds. Debita resolves this issue by additionally utilizing DSS as a liability token, where Debita would instead mint DSS and return it to redeemers, and amount minted would be *approximately* proportional to the utilization rate (at epoch t) Υ_t of the lending pool. Any minted DSS would be then burned with the repayed loans plus interest in subsequent epochs, with the intent of making DSS net-deflationary.

To illustrate this more concretely, where a typical collateralized stablecoin protocol would return the full collateral value during redemption, Debita would instead return $\omega * redeemamount + (1 - \omega) * redeemamount)$, where $\omega * redeemamount$ and $(1 - \omega) * redeemamount$ is the value of returned collateral and DSS, respectively. ω would be determined algorithmically via modeling the liquidity flow as a dynamical system, as is outlined below.

4.2.1 Algorithm for determining ω

This motivates the question as to how to determine ω, the ratio between additionally minted DSS and returned collateral. Intuitively, this decision would precipitate a trade-off between amount of returned collateral and utilization rate; the protocol should be incentivized to return the most amount of collateral to secure the trust of its users subject to the constraint that the pool should maintain a threshold level of liquidity at all times. This threshold is a pre-determined parameter that is akin to the ideal utilization ratio of a lending pool. It is then easy to see that this naturally reduces to a continuous control problem, where at timestep t a system should be designed to output ω_t that maximises the aforesaid trade-off for subsequent timesteps $\hat{t} \geq t$.

We then (informally) formulate this as a control problem and define the following variables;
a)let V_t be the total *expected* value of the pool. In simple terms this represents the total value that lenders have deposited.
b)let $\hat{V}_t$ be the total *real* value of the pool. This is simply the true amount present in the pool that subtracts amount of borrowed funds from V_t.
c)let i_t, o_t be the inflow from minting and outflow from redeeming at timestep t, respectively. i_T, $o_T \in \mathbb{R}^T$ is a vector with elements $i_t, o_t, t \in 1...T$.
d)let N_t be the variable that represents the repayments at next epoch. This is a random variable where the stochasticity is associated with the probability of defaults.
e)let b_t be the borrowed amount at timestep t.
Let us then define the following variables to formulate our objective as a control problem; the state vector at timestep t is denoted as $x_t \in \mathbb{R}^4$, where the elements in the array are comprised of $V_t, \hat{V}_t, MA_\mu(i_T), MA_\mu(o_T)$, and MA_μ is a function that computes the μ step moving average. The control variable $u_t \in \mathbb{R}^1$ is a scalar $\max(o_t)$, and the cost $C_t(x_t, u_t)$ is a function $\max(o_t) - \theta \mathbb{1}(\hat{V} \leq V_{threshold})$. Intuitively, a decision maker at timestep t is given the expected and real pool values, and the statistics of recent net flows. She is then required to decide what is the least amount of restriction of current outflows such that the real pool value is above a certain threshold for subsequent timesteps. The objective is finding the optimal control law,

$$u_T = \arg\min_{u_T} \sum_{i=t}^{t+n} C_i$$

$$s.t\; x_{t+1} = f(x_t, u_t)$$

.

We are equipped with the necessary information to derive the dynamics function f.

$$\hat{V}_{t+1} = \hat{V}_t + N_t + i_t - o_t - b_t$$

$$V_{t+1} = \sum_{i=t}^{t} (i_t - o_t)$$

$$N_t = (V_t - \hat{V}_t)(\gamma + \tilde{I})(1 + N(0, \beta))$$

Planning algorithms like model predictive control can be utilised to solve this optimization problem and obtain the optimal $\max(o_t)$, and $\omega = \min(\max(o_t)/\hat{o}_t, 1)$, where $\hat{o}_t$ would be the total requested redeem value at t.

4.3 Peg stability

Stability of DS is going to be maintained through two levers; a)minting and redeeming arbitrages and b)Dynamic yield distribution. This adds an another dimension of maintaining stability compared to alternative stablecoins.

Arbitrage Lever: When DS trades at a discount θ on exchanges, arbitrageurs will purchase DS from the open market at a price of $1 - \theta$ USD and redeem it from Debita for 1 USD worth of value, collecting θ risk-free profit. Similarly when DS trades at a premium θ on exchanges, arbitrageurs will mint DS from Debita by depositing 1 USD worth of value and sell it on the open market for $1 + \theta$ USD, collecting θ risk-free profit.

Yield Distribution Lever: Instead of distributing interest rate to DS holders uniformly Debita will instead accrue interest rates paid by the borrowers in the LendingPool contract and distribute them in such a manner that increases demand for DS when below the peg, and vice versa. When DS is trading below 1 USD or the time averaged net outflows are above a certain threshold, Debita will increase the distributed rewards among holders, and when DS is trading above the peg or the time averaged net outflows are below a certain threshold, it will decrease the distributed rewards among holders.