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Simulating the MakerDAO Stablecoin

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***Abstract*—We present a computational simulation framework for the single-collateral stablecoin launched by the MakerDAO project. The simulator, called DAISIM, models investors as portfolio optimizers with heterogeneous risk preferences, and incorporates automated order matching and price update mechanisms to determine the DAI price. DAISIM is being made available as open-source and may be useful in evaluating other similar projects.**

I. Introduction

A stablecoin [1, 2] is a digital token that is designed to minimize price volatility against a peg, such as the US Dollar. By achieving stability, these tokens have a higher potential to be utilized as a medium of exchange compared to volatile cryptocurrencies. One of the prominent projects is MakerDAO [3], a decentralized Stablecoin project on Ethereum blockchain launched in 2017.

We have developed DAISIM, a computational simulation framework for modeling the MakerDAO system, to understand how well its underlying mechanism works under different settings. The crux of our model is to focus on the population of investors and investigate whether and when they choose to mint or burn DAI, and when they choose to buy and sell ETH or DAI. We model the investors using Markowitz Optimal Portfolio Theory [4] with heterogenous risk preferences. Our simulator iteratively updates the price of DAI and matches buyers and sellers to determine the market clearing or settling price. It allows us to set and modify various exogenous parameters such as return and risk associated with various assets and the price of ETH as well as system parameters such as interest rate (known as stability rate in the MakerDAO ecosystem) and transaction fees, allowing us to examine how the DAI price depends on these various parameters. The simulator is made available as an open-source simulation tool for use by the research community online at https://github.com/ANRGUSC/DAISIM

II. MakerDAO - Background

We model single-collateral DAI (SAI), which could only be generated through a Collateralized Debt Position (CDP), a smart contact that requires the user to lock in excess collateral above a minimum ratio called Liquidation Ratio in order to mint DAI. A CDP can be closed at any time once the debt and the CDP Interest Rate (Stability Rate) are paid. If the collateralization ratio drops to the liquidation ratio, the CDP is automatically liquidated by the system. After the debt, Stability Rate and Liquidation Penalty have been recovered, the left-over collateral is returned to the CDP owner. When the value of DAI is below the Target Price, increasing the Stability Rate incentives users to close CDPs, and when the value of DAI is above the Target Price, decreasing the Stability Rate incentivizes users to open more CDPs. Thus, it helps stabilize the price of DAI.

III. Design of the DAISIM Simulator

Considering that the Maker protocol has rapidly evolved in the last few years, this paper will assume that DAI mentioned in the subsequent sections refers to single-collateral DAI (SAI) for brevity.

A. System model

Our full system model for the single-collateral DAI ecosystem and our simulator is as shown in Figure 1. Exogenous inputs to the model include the price of ETH, expected return and risk (covariance) for USD, ETH, DAI and cETH. System parameters include the Stability Rate r_s and the Transaction Fees β. Additional simulation parameters include the size of the market n (number of investors), their risk profile (captured by a weight parameter λ_i for the i^{th} investor), and parameters pertaining to the price update algorithm employed in the simulation. The simulator allows investors to buy ETH on an open market as per the current ETH price P_{ETH}; it allows investors to open and close CDP's per the current stability rate; and it allows investors to buy and sell DAI from/to each other in the simulated market. All these transactions incur a constant transaction fee as specified by β. The simulator takes care of matching buy/sell orders for DAI and determining the market clearing (settling) price for DAI P_{DAI}. We describe these mechanisms in more detail below.

B. Price Settling Algorithm

The Price Settling Algorithm involves three steps i.e., Asset Optimization Mechanism, Order Matching Mechanism, and the Price Update Mechanism. We assume n investors each with an initial asset holdings $\mathbf{x}$ and a risk tolerance parameter λ. It is assumed that if λ is low, then the investor is risk-tolerant, and if it is high, then the investor is risk-averse. For each of these investors, we use the asset optimization mechanism to find out an optimal portfolio, x^{opt} and then use the Order Matching Mechanism to verify if all DAI Buy orders, B and the Sell Orders, S can be met. This mechanism proposes a new asset allocation of $x_{i,j}^M$ for the asset

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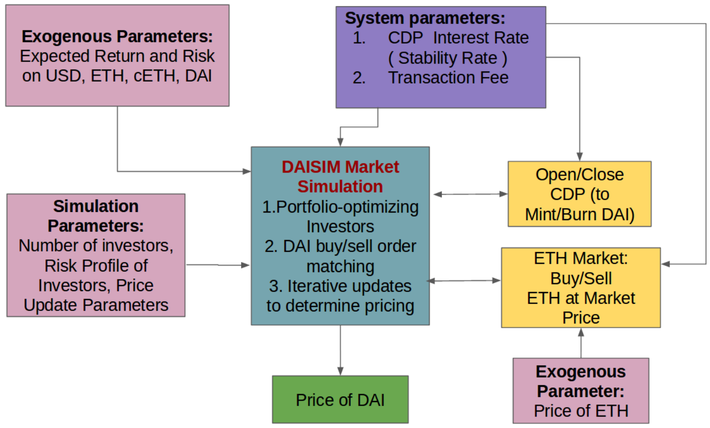

Figure 1. Overview of the DAISIM Simulator

$j \in \{USD, ETH, DAI, cETH\}$ of the i^{th} investor based on $x^{opt}_{i,j}$. Then using the price update mechanism, we estimate the supply/demand of DAI based on the DAI bought/sold by the investors to achieve the optimal allocation and then update the DAI price, P_{DAI}.

1) Asset Optimization Mechanism: For an i^{th} investor, consider the vector $\mathbf{x} = [x_{i,1}, x_{i,2}, x_{i,3}, x_{i,4}]$ which represents the i^{th} investor's holdings in each asset class: USD, ETH, DAI and cETH, respectively. We assume that the investor collateralizes at a constant safety ratio ρ that is well above the liquidation ratio of the protocol. Let r_s represents the stability rate. Let μ be the vector of expected return on investment in each of the four assets, and let $\mathbf{\Sigma}$ be the covariance matrix associated with the value of these assets. Let β be the transaction fee to buy or sell 1 USD worth of ETH/DAI and Ψ be the overall transaction fee incurred to reach the optimal allocation.
An optimal portfolio i.e., x^{opt} for the i^{th} investor with a total initial investment capital of $m = \Sigma x$ corresponds to one that maximizes:

$$\mathbf{x}^T \mu - \lambda \mathbf{x} \mathbf{\Sigma} \mathbf{x}^T - \frac{x_{i,4}}{\rho} r_s - \Psi \tag{1}$$

with some additional constraints (omitted here for brevity) that model the transaction fees.

2) Order Matching Mechanism: We assume that the market doesn't have any external source of DAI, thus we need to make sure that the total DAI in the market is fixed during the course of the Price Settling Algorithm. Let B denote the total outstanding buy order, and S represents the total outstanding sell order in the market. If $B > S$ i. e. buy orders exceed sell orders, then all the sell orders can easily be met whereas when $S > B$ all buy orders can easily be met. In case all buy and sell orders cannot be met, the buy/sell order of an i^{th} investor is achieved in proportion to the amount of DAI they want to buy/sell to reach their optimal allocation.

3) Price Update Mechanism: It is evident from the above discussion that the Asset Optimization Mechanism estimates the market's demand for DAI whereas the Order Matching Mechanism tries to fulfill the demand keeping total DAI in the market constant. The Price Update Mechanism updates the price P_{DAI} based on the supply and demand of DAI in the market. If the amount of DAI demanded is more than the DAI minted by CDP's then the price is raised, else it is lowered.

IV. Conclusions

We have developed DAISIM, an open-source computational simulation of the single-collateral DAI stablecoin from MakerDAO. In future work this simulation could be used to develop automated mechanisms to steer or control the price of DAI by modifying relevant control parameters. And it could be extended to handle the newer multi-collateral version of DAI that has been introduced more recently.

Acknowledgment

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