

Decentralized Finance

Lending and Borrowing

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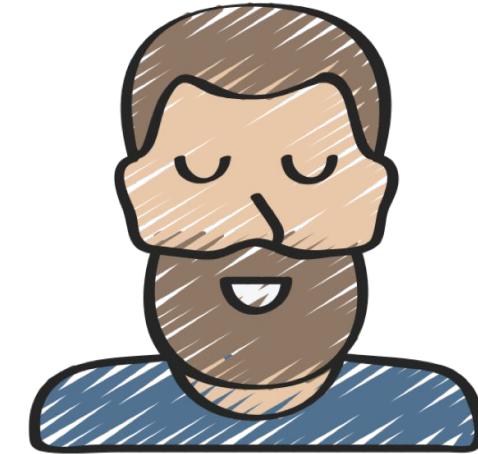
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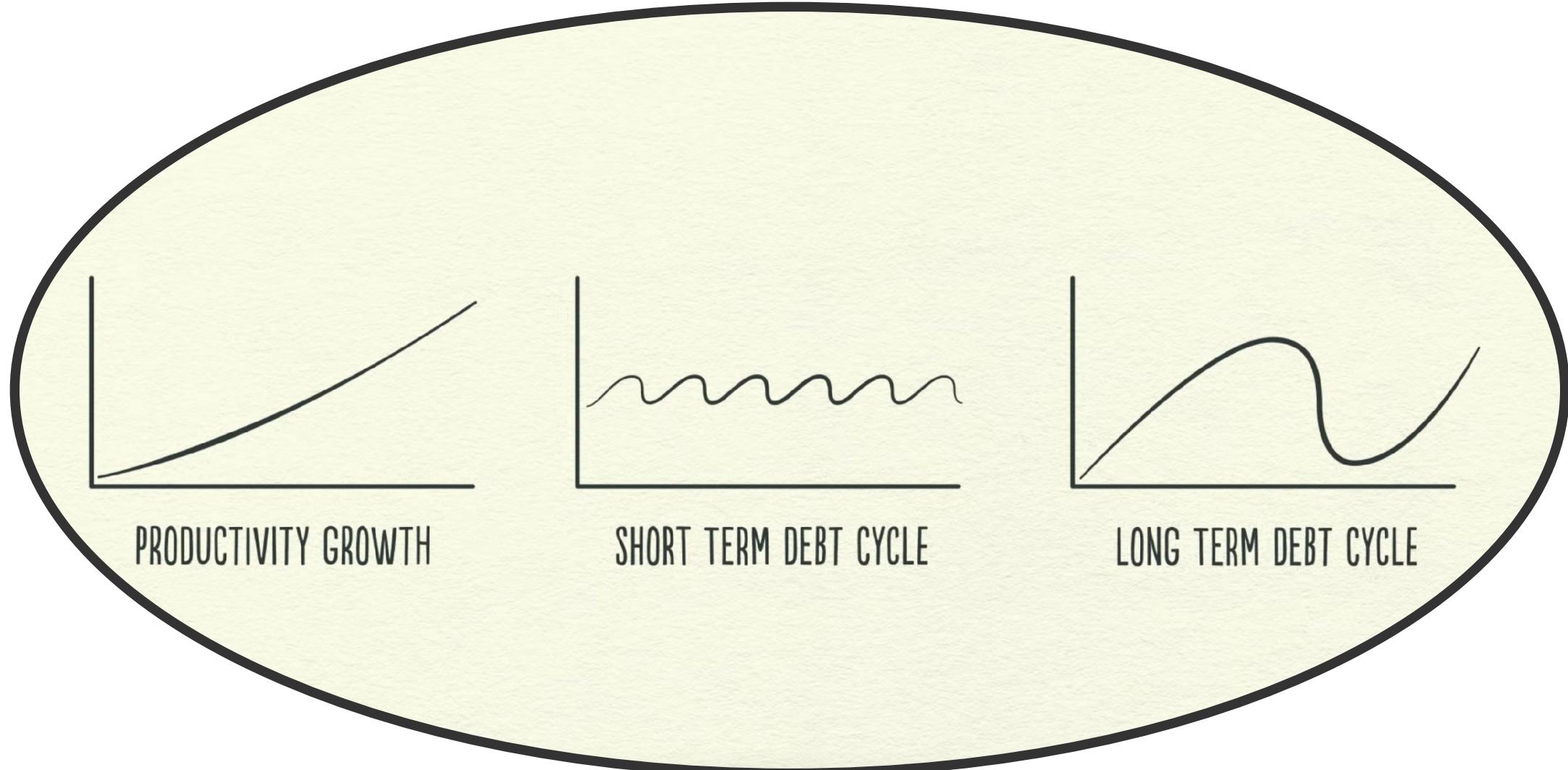
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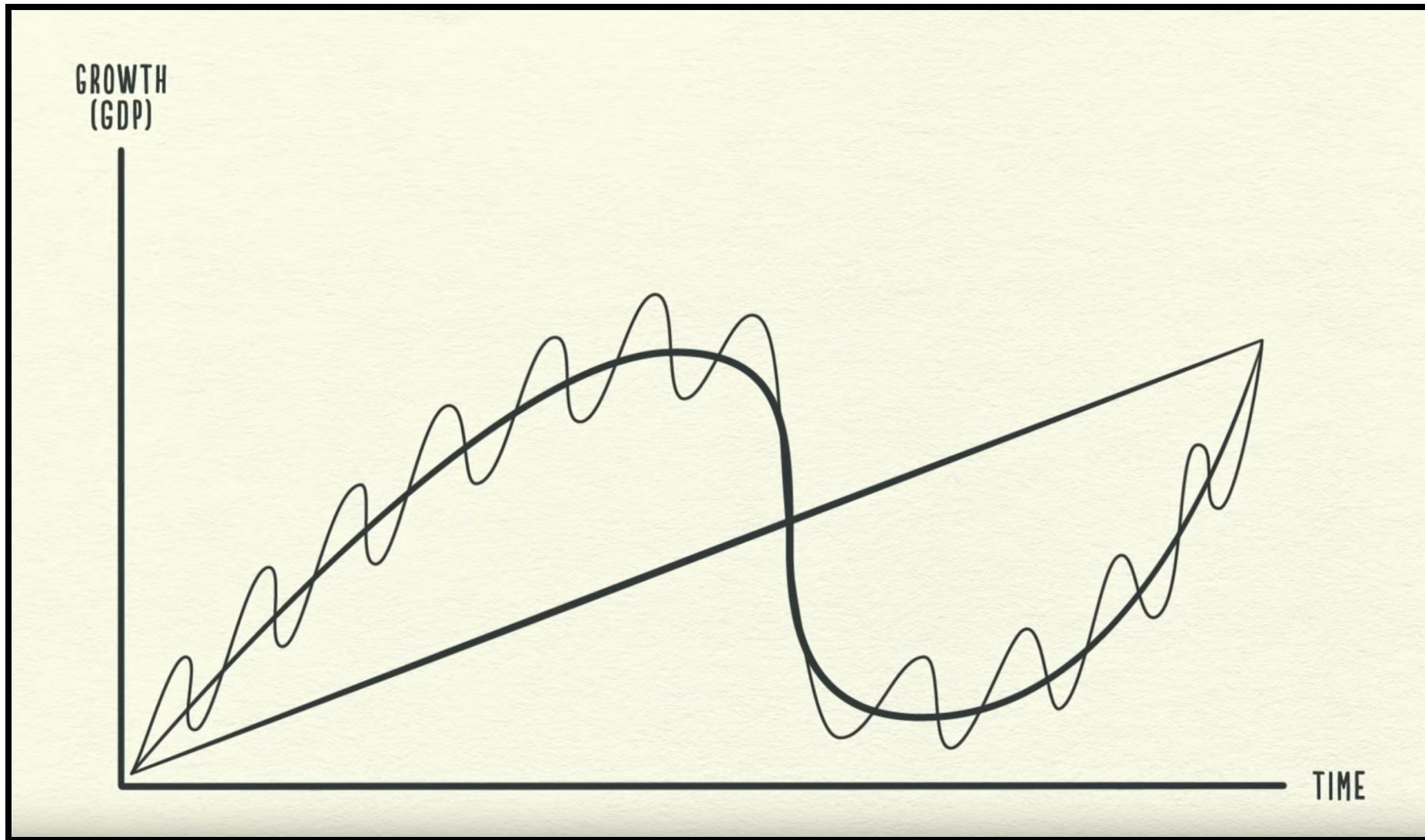
Why lending?



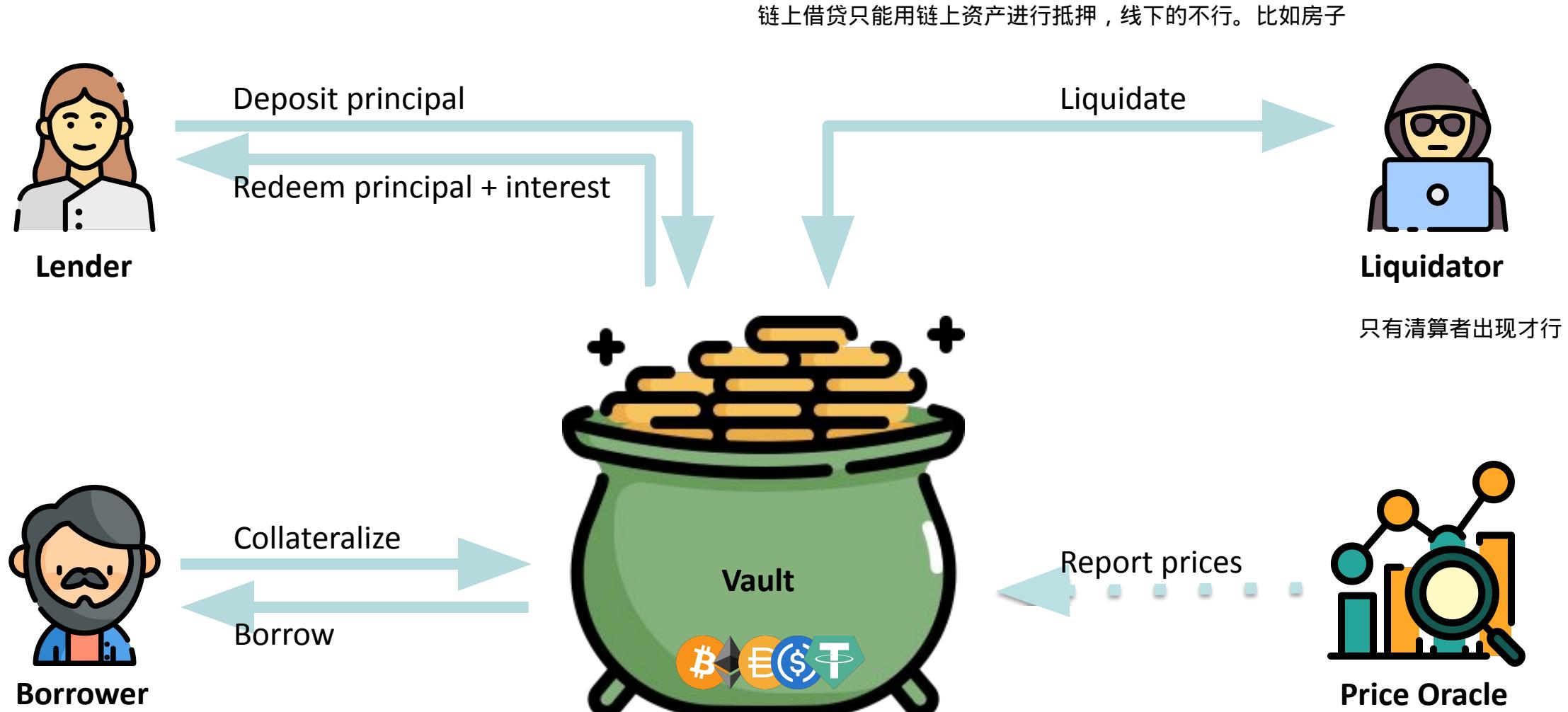
How the “Economic Machine” works?



How the “Economic Machine” works?



On-Chain Lending & Borrowing



Leverage == A debt multiplier

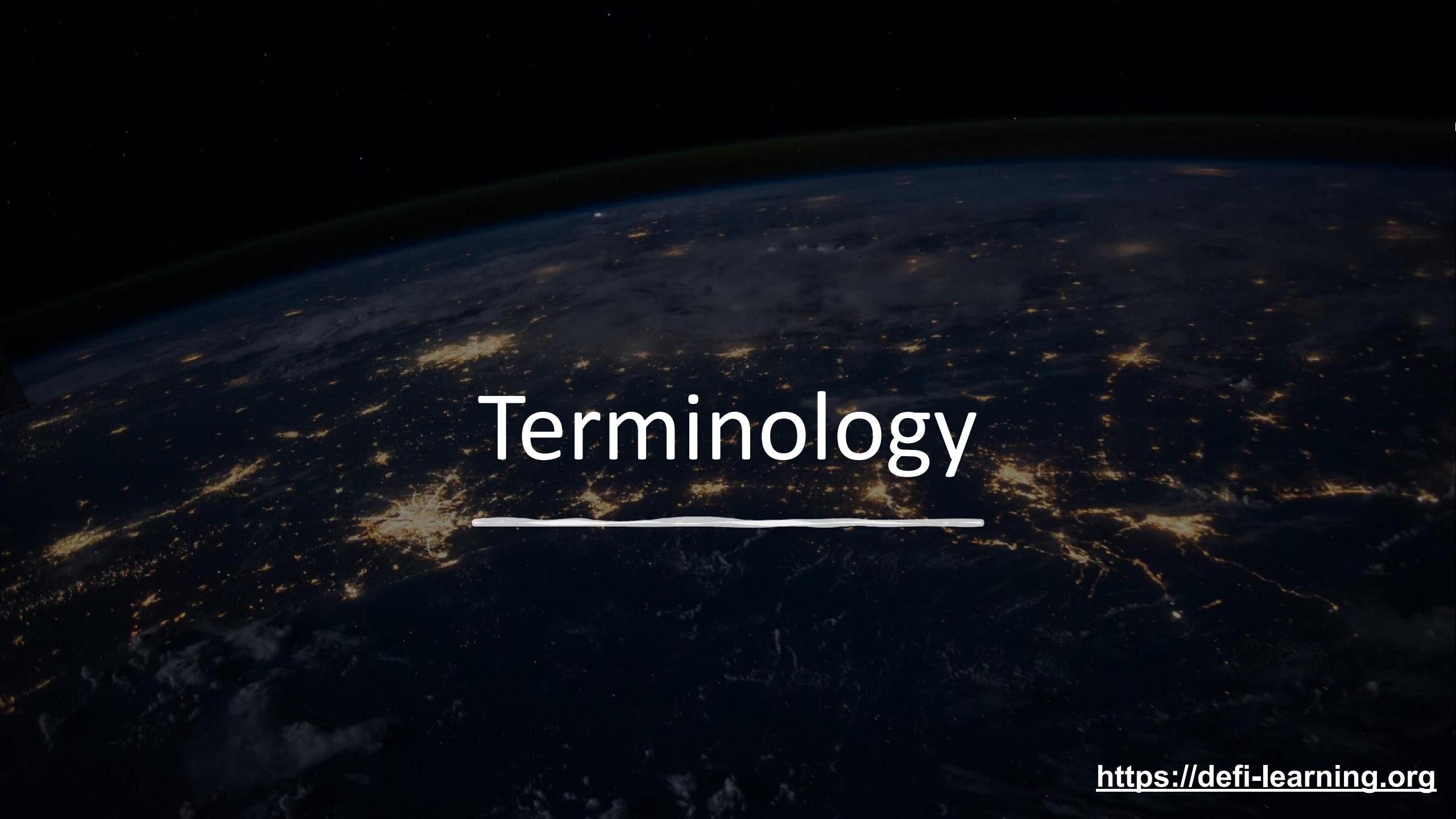
Assets	Market size	Total borrowed	Deposit APY	Borrow APR	Stable Borrow APR	
DAI	\$ 1.55B	\$ 1.2B	2.77% 0.10% APR	3.89% 1.41% APR	11.95%	<button>Deposit</button> <button>Borrow</button>
Gemini Dollar (GUSD)	\$ 38.17M	\$ 30.64M	3.89% 2.40% APR	5.39% 2.99% APR	—	<button>Deposit</button> <button>Borrow</button>
USD Coin (USDC)	\$ 5.59B	\$ 4.18B	2.27% 0.93% APR	3.32% 1.26% APR	10.66%	<button>Deposit</button> <button>Borrow</button>
USDT Coin (USDT)	\$ 1.15B	\$ 1.04B	9.02% 2.83% APR	10.99% 3.15% APR	18.99%	<button>Deposit</button> <button>Borrow</button>
Wrapped ETH (WETH)	\$ 4.51B	\$ 206.35M	0.02% 0.54% APR	0.56% 0.63% APR	3.70%	<button>Deposit</button> <button>Borrow</button>
WBTC Coin (WBTC)	\$ 1.58B	\$ 96.71M	0.04% 1.24% APR	0.75% 1.07% APR	3.94%	<button>Deposit</button> <button>Borrow</button>
Sushiswap USDC/ETH	16.96%	Alpha APR Borrow APR	22.98% -14.55%	FARM		
Yield Farming Sushiswap MKR/ETH	18.44 %	Yield Farming Trading Fee Alpha APR Borrow APR	9.75 % 3.80 % 13.37 % -8.47 %	FARM		
Yield Farming Sushiswap ETH/USDT	46.83 %	Yield Farming Trading Fee Alpha APR Borrow APR	19.02 % 19.38 % 22.98 % -14.55 %	FARM		
Yield Farming Sushiswap DAI/ETH	49.25 %	Yield Farming Trading Fee Alpha APR Borrow APR	20.95 % 19.88 % 22.98 % -14.55 %	FARM		
Yield Farming Curve 3pool	17.47 % 4.26 %	Yield Farming Trading Fee Alpha APR Borrow APR	22.48 % 7.45 % 46.74 % -59.20 %	FARM		

7x leverage

Curve pools \$

Pool	Base APY	Rewards APY	Volume
tricrypto CRYPTO V2 [?]	2.61%	+2.27%→5.67% CRV	\$15.2m
3pool USD DAI+USDC+USDT	1.08%	+3.16%→7.90% CRV	\$226.1m
ust USD UST+3Crv	5.72%	+3.77%→9.42% CRV	\$21.9m
bbtc BTC BBTC+sbtcCrv	0.53%	+3.13%→7.81% CRV	\$9.5m
sUSD USD DAI+USDC+USDT+sUSD	0.48%	+2.74%→6.86% CRV +2.04% SNX	\$8.7m
lUSD USD LUSD+3Crv	1.04%	+6.17%→15.43% CRV	\$8.7m
alUSD USD aLUSD+3Crv	0.78%	+1.85%→4.64% CRV +11.18% ALCX	\$5.8m
tricrypto2 CRYPTO V2 [?]	2.88%	+0.00%→0.00% CRV	\$4.8m
seth ETH ETH+sETH	2.19%	+2.02%→5.06% CRV	\$3.8m
steth ETH ETH+stETH	2.91%	+0.15%→0.37% CRV +6.03% LDO	\$2.6m

[See All Pools](#) [My Dashboard](#)

A nighttime satellite view of Earth from space, showing city lights and auroras.

Terminology

Terminology

术语

- **Collateral** 抵押物
 - Assets that serve as a security deposit
- **Over-collateralization** 超额抵押
 - Borrower has to provide $\text{value}(\text{collateral assets}) > \text{value}(\text{granted loan})$
- **Under-collateralization** 抵押不足
 - $\text{value}(\text{collateral}) < \text{value}(\text{debt})$
- **Liquidation** 清算
 - If $\text{value}(\text{collateral}) \leq 150\% \times \text{value}(\text{debt})$
 - Anyone can liquidate the debt position

Health Factor

$$Health\ Factor = \frac{\sum Value\ of\ Collateral_i \times Liquidation\ Threshold_i}{Total\ Value\ of\ Debts}$$

清算阈值
Borrowing Capacity

- $0 < Liquidation\ Threshold < 1$
- The **liquidation threshold** provides a “secure” margin
- When the health factor declines below 1, a borrowing position becomes liquidatable

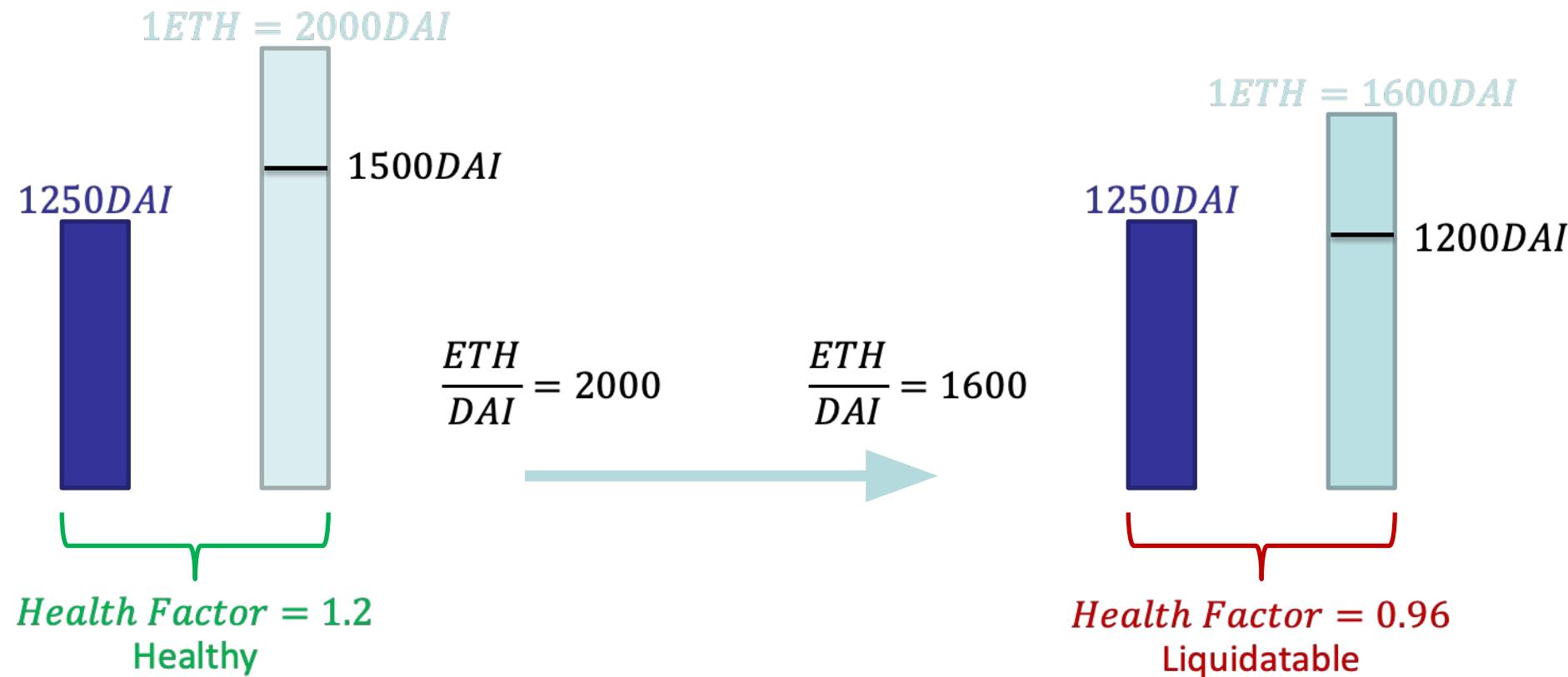
当健康因子下降到1以下时，借款头寸变得可清算

现在的清算基本上都是有时延的，比如说48小时，留给用户补仓的时间。避免特殊时期导致市场的波动

Health Factor

Debt — Borrowing Capacity

Collateral *Liquidation Threshold = 0.75*



Terminology

清算价差

- **Liquidation Spread LS:** bonus, or discount, that a liquidator can collect when liquidating collateral

当清算人清算某个借款人的抵押品时，他们会获得比所偿还债务更多的抵押品，这个额外的部分就是由清算差价决定的。比如，如果LS为0.1（即10%），清算人清算的抵押品价值将是债务价值的110%。（也就是说，多出来的钱是由清算人获得的）

$$\text{Value of Collateral to Claim} = \text{Value of Debt to Repay} \times (1 + LS)$$

要求的抵押物价值

- **Close Factor CF:** the maximum proportion of the debt that is allowed to be repaid in a single fixed spread liquidation

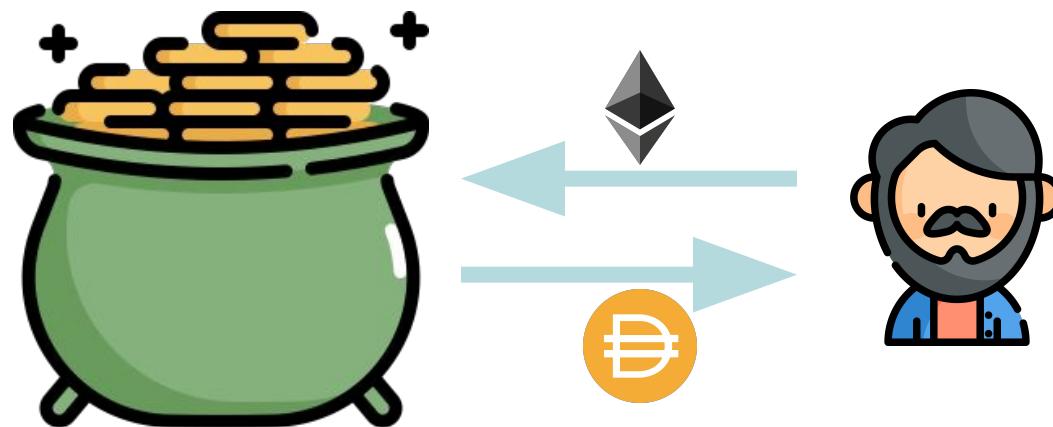
$$\text{Value of Debt to Repay} < CF \times \text{Total Value of Debts}$$

关闭因子表示一次可以清算的价值的比例。不能一个人把蛋糕吃完。



Over-collateralized Borrowing

Over-collateralized Borrowing

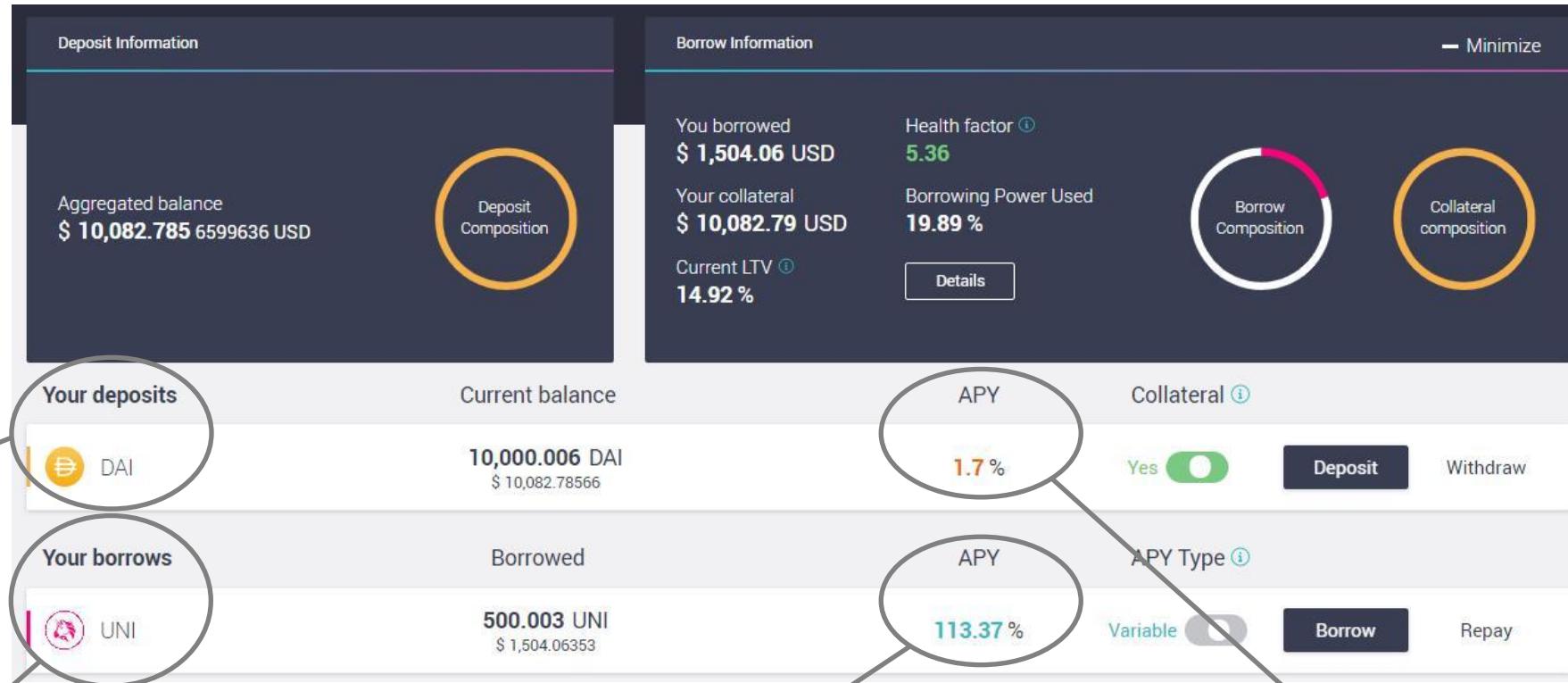


- E.g., the borrower collateralizes ETH and borrows DAI
- The value of ETH exceeds the value of DAI
- The borrower can use the borrowed DAI arbitrarily/freely

但是无法加杠杆，资本利用率还是比较低的。毕竟是超额抵押

Over-collateralized Borrowing

Aave Dashboard Screenshot



DAI is deposited as collateral

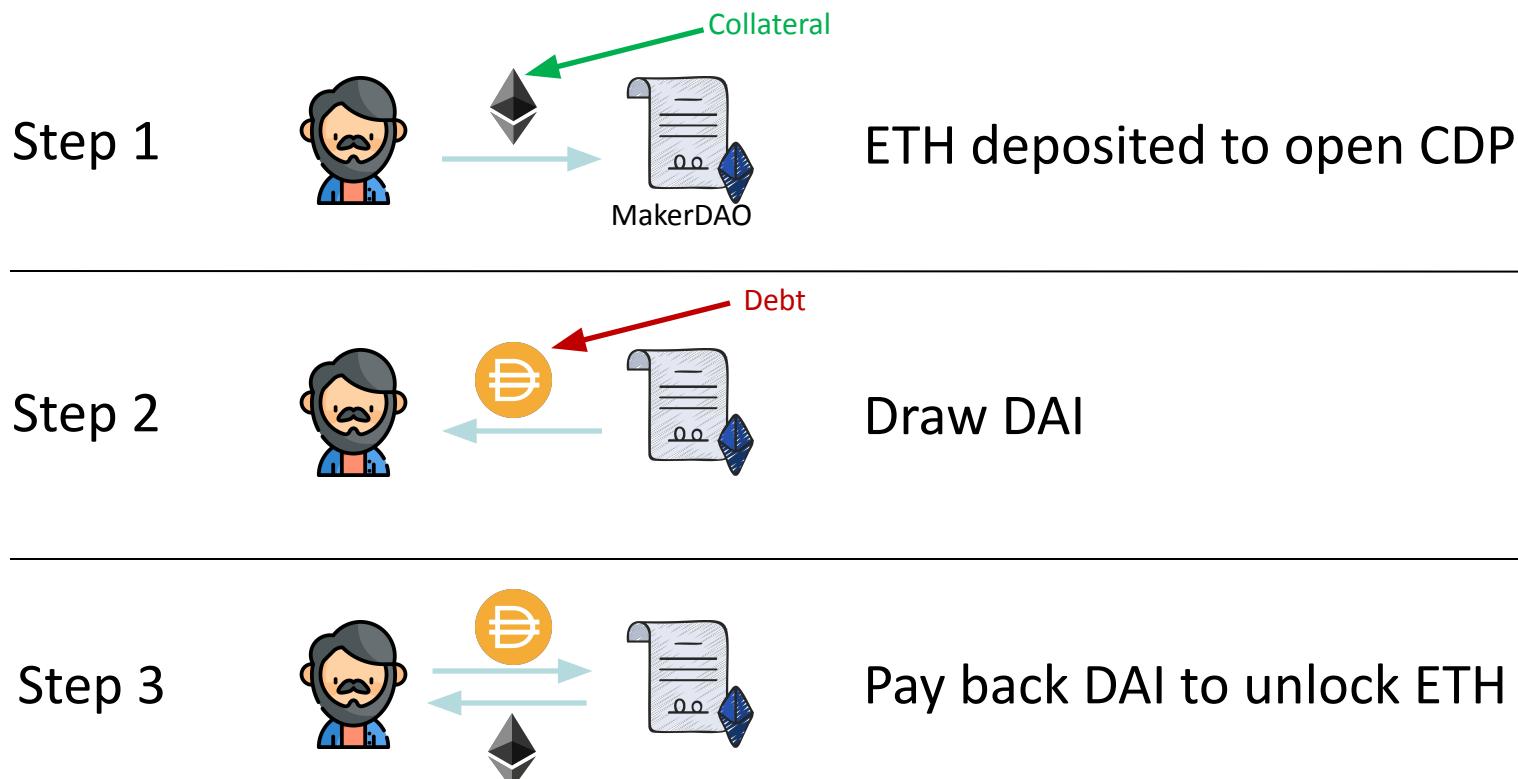
UNI is borrowed

The borrowing interests
the borrower needs to pay

In Aave, the collateral is also lent out. Hence
the borrower can also earn interests.

Over-collateralized Borrowing

Stablecoin



Under-collateralized Borrowing

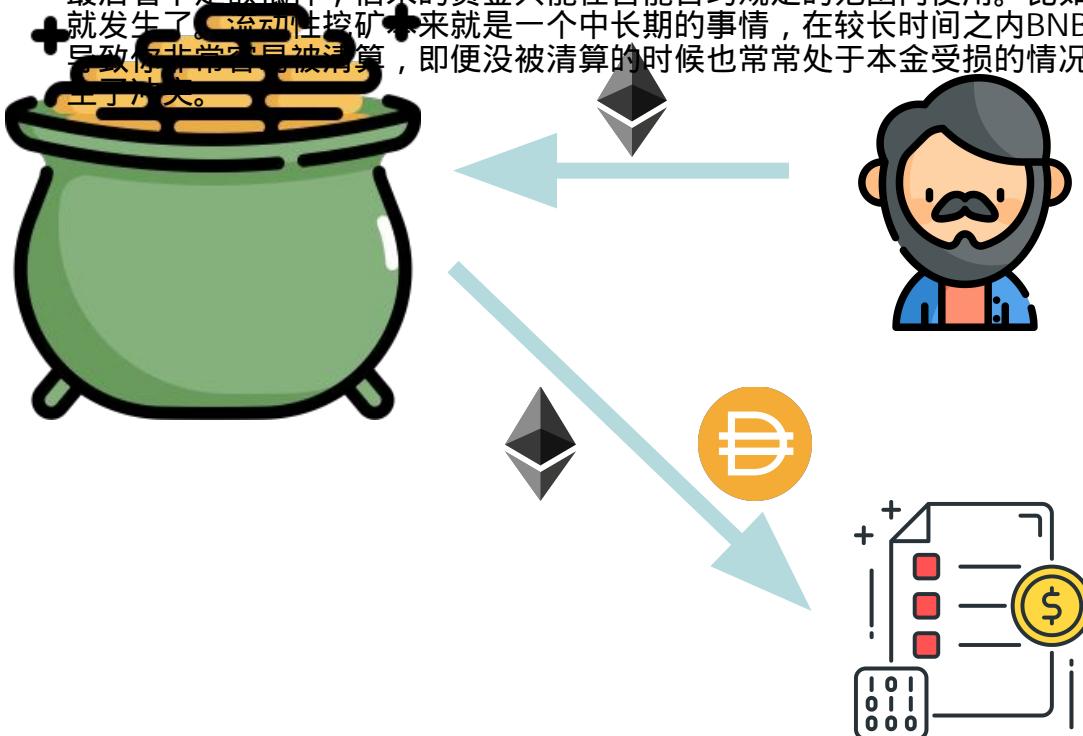
抵押不足的贷款

Under-collateralized Borrowing

带杠杆的不足额抵押借贷被市场抛弃是因为风险太大。我挖过AH，借出债务是BNB，赶上BNB价格飞涨，收益直接成为负数认亏30%出场了。
对比其它DEFI生息的操作风险收益比太低了：

- 1、单币质押给的年化可能很高，但币价本身波动会让收益大幅减少，相当于减少了持币不动的风险，让打算长期持有的币生息，不会有清算风险。
- 2、流动性挖矿有无常损失，ETH/USDT流动性挖矿是币价上涨赚的少，币价下跌亏得少，本质上是对持币不动的风险和收益都做了一定的稀释，也不会有清算风险。

3、直接超额借贷，你拿着钱做任何事情都可以，只需要注意抵押率安全别被清算。
最后看不足额抵押，借来的资金只能在智能合约规定的范围内使用。比如AH是让你用3倍杠杆去做流动性挖矿，参与BNB/USDT的流动性挖矿，然后离谱的事情就发生了。流动性挖矿本来就是一个中长期的事情，在较长时间之内BNB的币价一定会上窜下跳的。然后这种上窜下跳的波动会放大地作用在你的抵押资产上，导致你非常容易被清算，即便没被清算的时候也常常处于本金受损的情况。本来想赚快钱而加杠杆，但加杠杆借来钱却只能去做赚慢钱的流动性挖矿，这就产生了冲突。

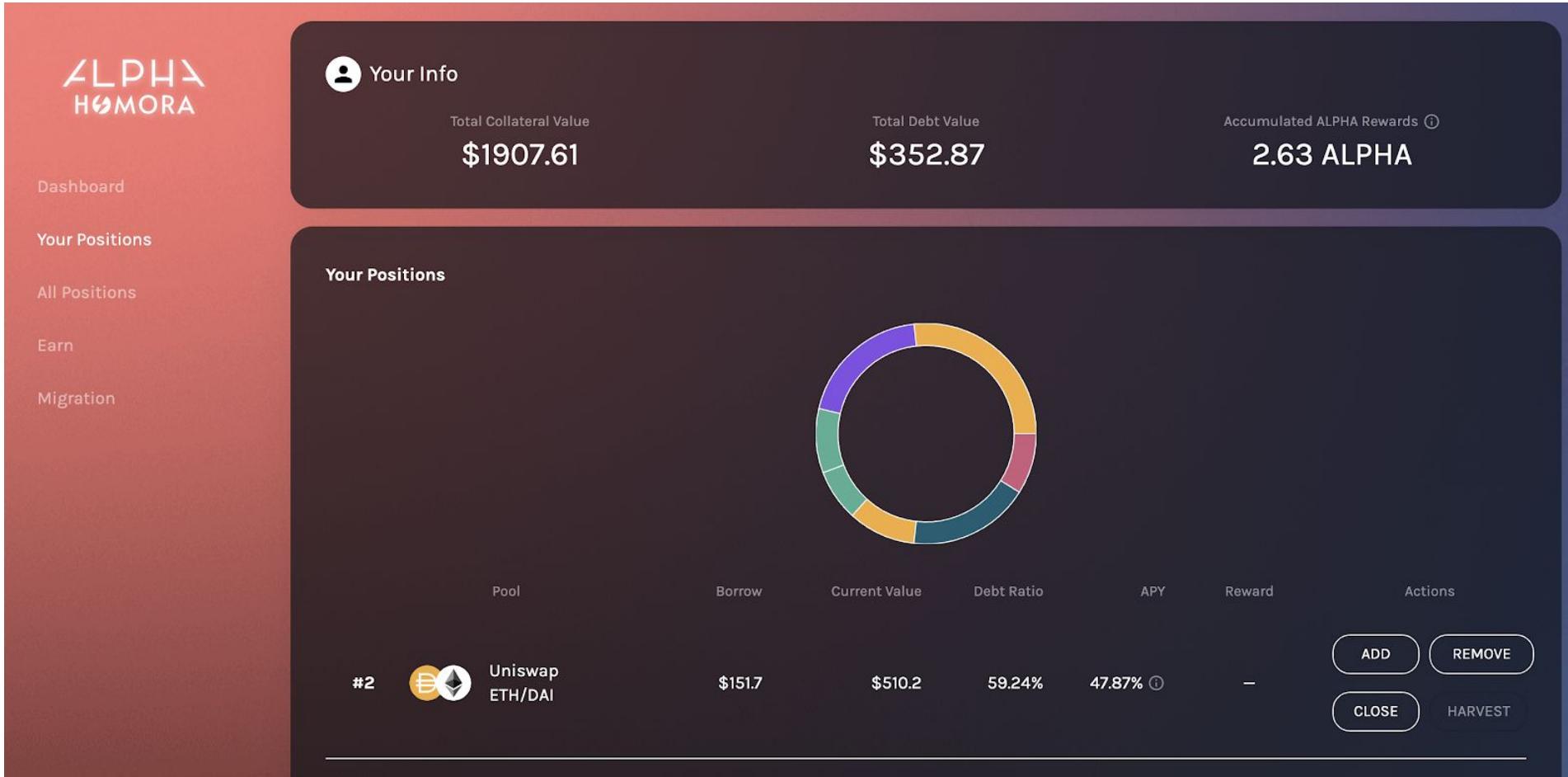


E.g., the borrower collateralizes ETH and borrows DAI

- The value of DAI (debt) can exceed the value of ETH (collateral)
- The collateralized ETH and borrowed DAI are restricted to be used with pre-designed smart contracts. Those are typically farming contracts.
- The vault remains in control of all assets.

Under-collateralized Borrowing

Alpha Homora Dashboard Screenshot



Under-collateralized Borrowing

Alpha Homora All Positions

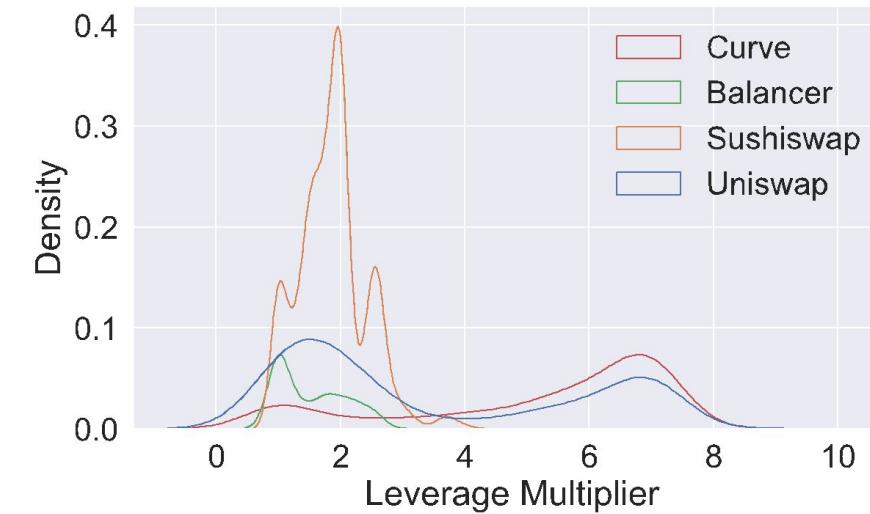
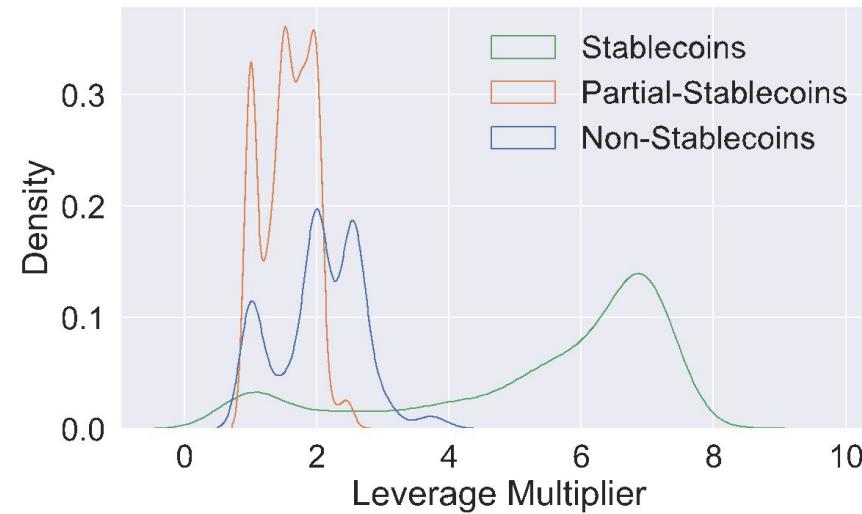
All Positions	#	Pool	Collateral Value	Borrow Credit ⓘ	Collateral Credit ⓘ	Debt Ratio ⓘ	Action
	#457	Sushiswap YFI/ETH	\$1,071,645.78	352.51	358.95	98.20% ⓘ	LIQUIDATE
	#852	Sushiswap ETH/CRV	\$55,776.51	15.34	15.71	97.67% ⓘ	LIQUIDATE
	#1425	Uniswap ETH/CRV	\$9,500.32	2.60	2.68	97.12% ⓘ	LIQUIDATE
	#1967	Sushiswap DAI/ETH	\$10,679,094.22	3,763.38	3,879.48	97.01% ⓘ	LIQUIDATE
	#366	Curve 3pool	\$57,460.63	24.22	25.04	96.72% ⓘ	LIQUIDATE
	#1922	Sushiswap SNX/ETH	\$29,583.59	8.81	9.11	96.69% ⓘ	LIQUIDATE
	#492	Uniswap UNI/ETH	\$27,551.56	7.50	7.76	96.67% ⓘ	LIQUIDATE
	#247	Curve 3pool	\$69,507.61	29.28	30.29	96.66% ⓘ	LIQUIDATE
	#245	Uniswap USDC/USDT	\$565,634.18	238.22	246.52	96.63% ⓘ	LIQUIDATE
	#936	Sushiswap WBTC/ETH	\$27,944.79	9.81	10.15	96.61% ⓘ	LIQUIDATE
	#129	Curve 3pool	\$35,263.71	14.84	15.37	96.58% ⓘ	LIQUIDATE

AH Statistics

- Opened Positions (October 2020 – August 2021)
 - 3800 borrowers
 - 10,430 leverage positions
- Leverage multipliers 杠杆乘数
 - AHv1: 2.01x
 - AHv2: 3.07x
- Stablecoin leverage multipliers 杠杆乘数
 - 5.39x

How are borrowers choosing leverage multipliers?

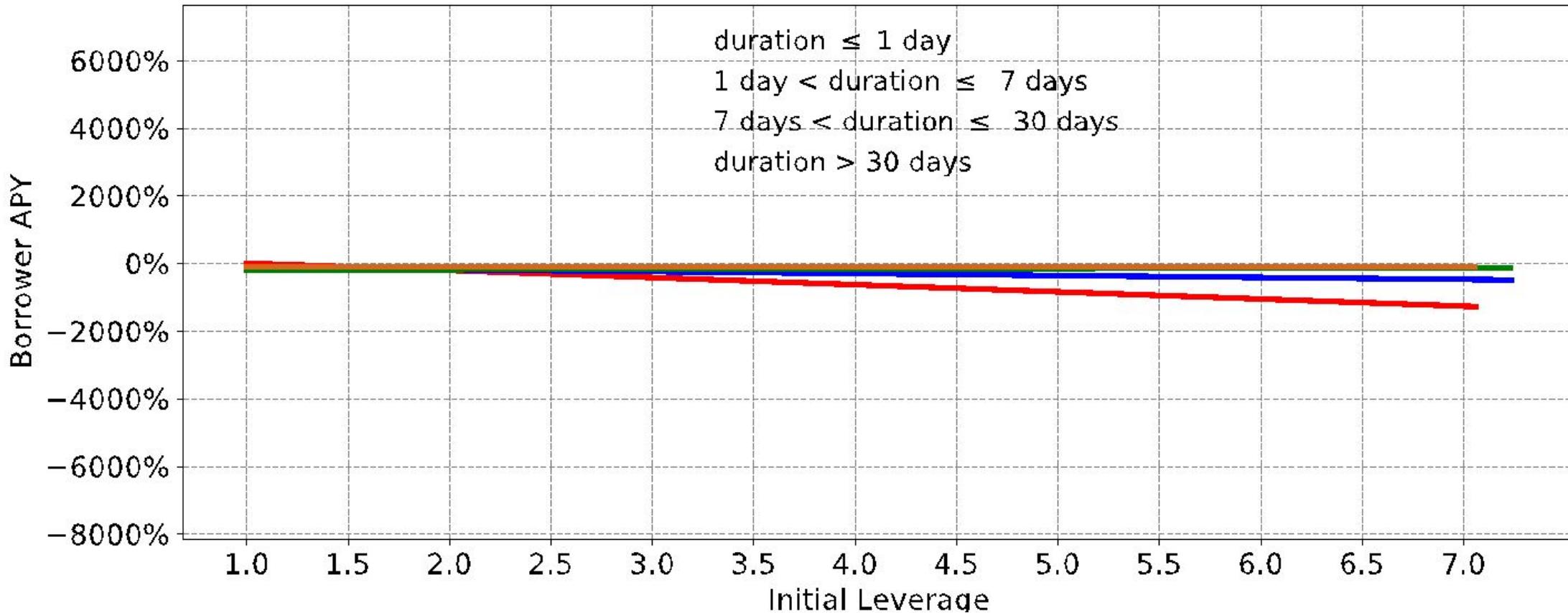
过时的知识了，现目前没什么意义



- Distributions of leverage multipliers in Alpha Homora V2 (2581 positions).

APY under Leverage

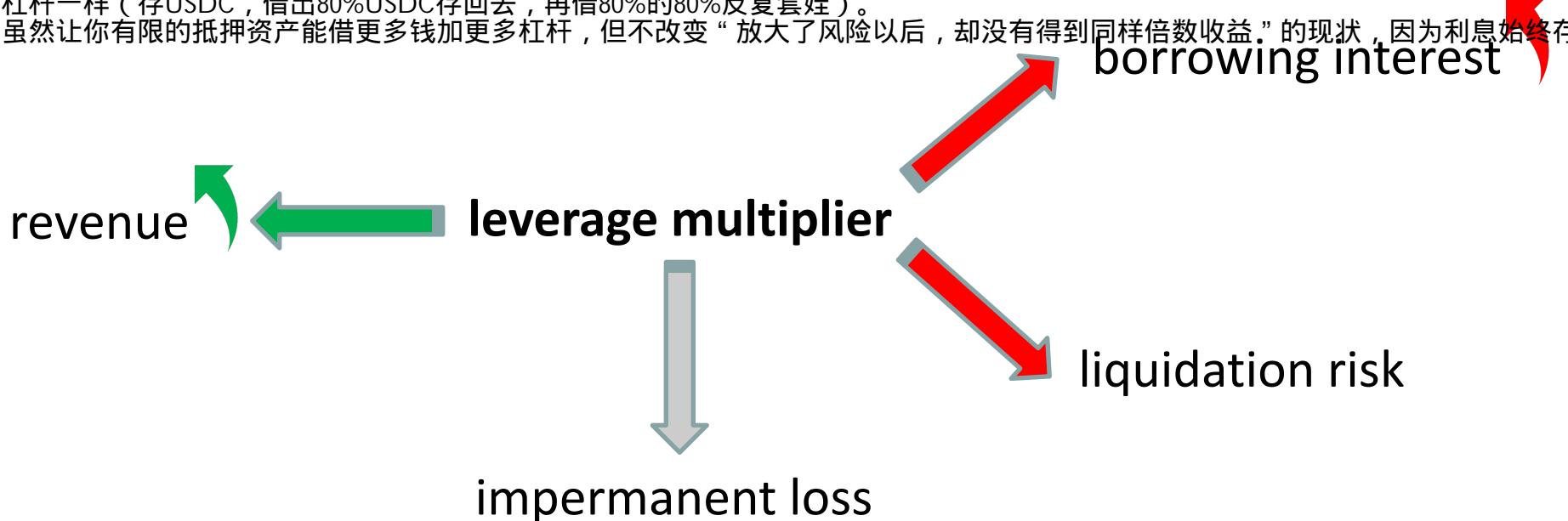
过时的知识了，现目前没什么意义



APY under Leverage

Why does leverage not amplify APY in practice?

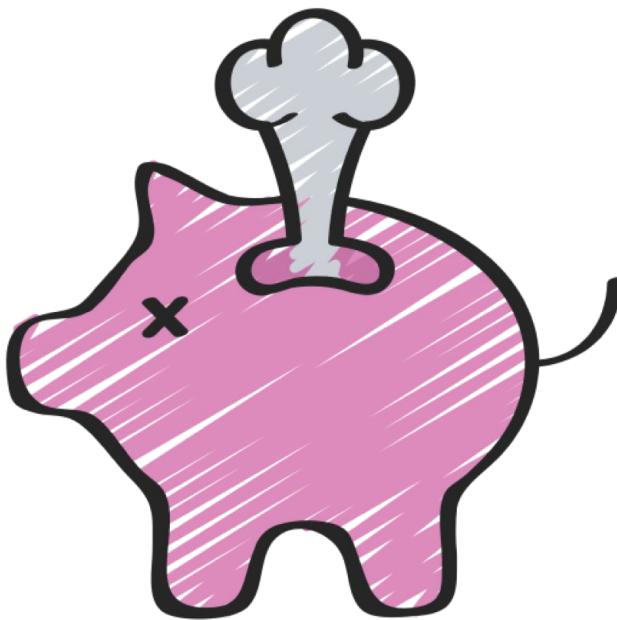
不能放大APY的本质是，你加2倍杠杆，理论上你的收益应该也是2倍，但你同时还需要支付给借款人利息，导致加了2倍的风险实际收益却只有1.5倍，加的杠杆越多，风险极速提升，收益却提升不大，显得很鸡肋。
这提点不会因为LP可以作为抵押物而有本质改变，加杠杆本质上就是风险扩倍，收益扩倍。LP能抵押只是增加了你加杠杆的上限，就像之前在借贷协议里用循环贷的方式加杠杆一样（存USDC，借出80%USDC存回去，再借80%的80%反复套娃）。
这种行为虽然让你有限的抵押资产能借更多钱加更多杠杆，但不改变“放大了风险以后，却没有得到同样倍数收益。”的现状，因为利息始终存在。





Liquidation

What could go wrong?

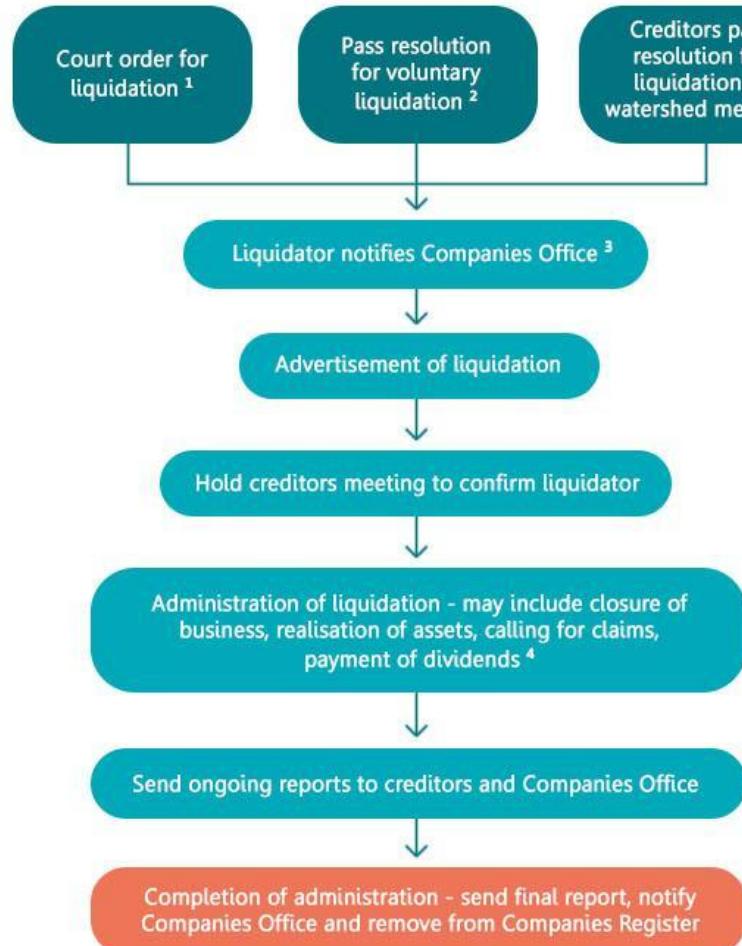


Liquidation

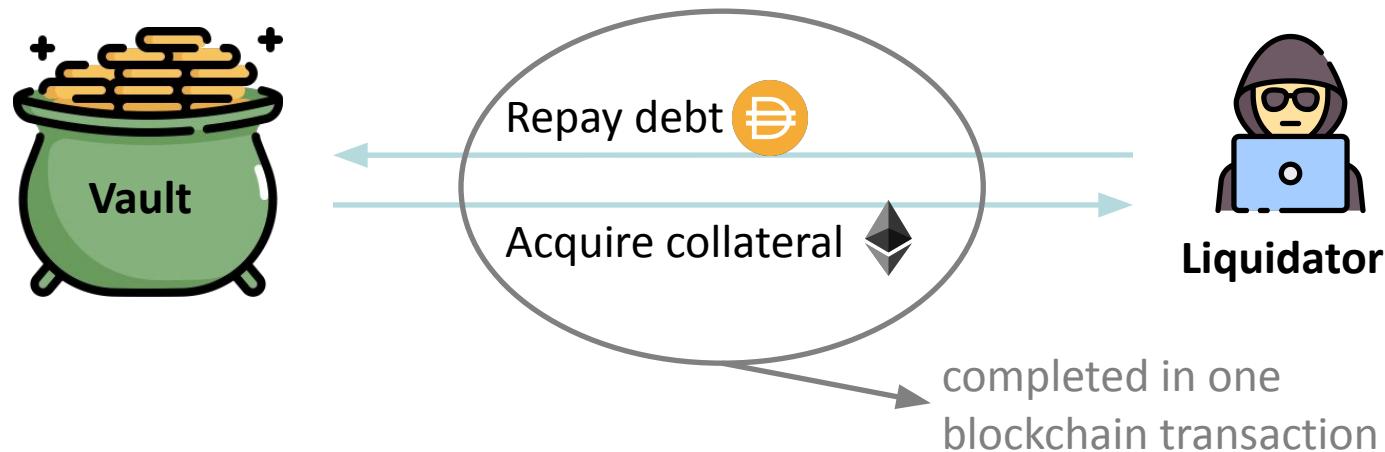
- Liquidation == Selling collateral from the borrower
- Liquidation Spread
 - Bonus, or discount for liquidator
 - Fixed spread, or variable (auction based)

基于拍卖

Liquidation in Traditional Finance



Fixed Spread Liquidation



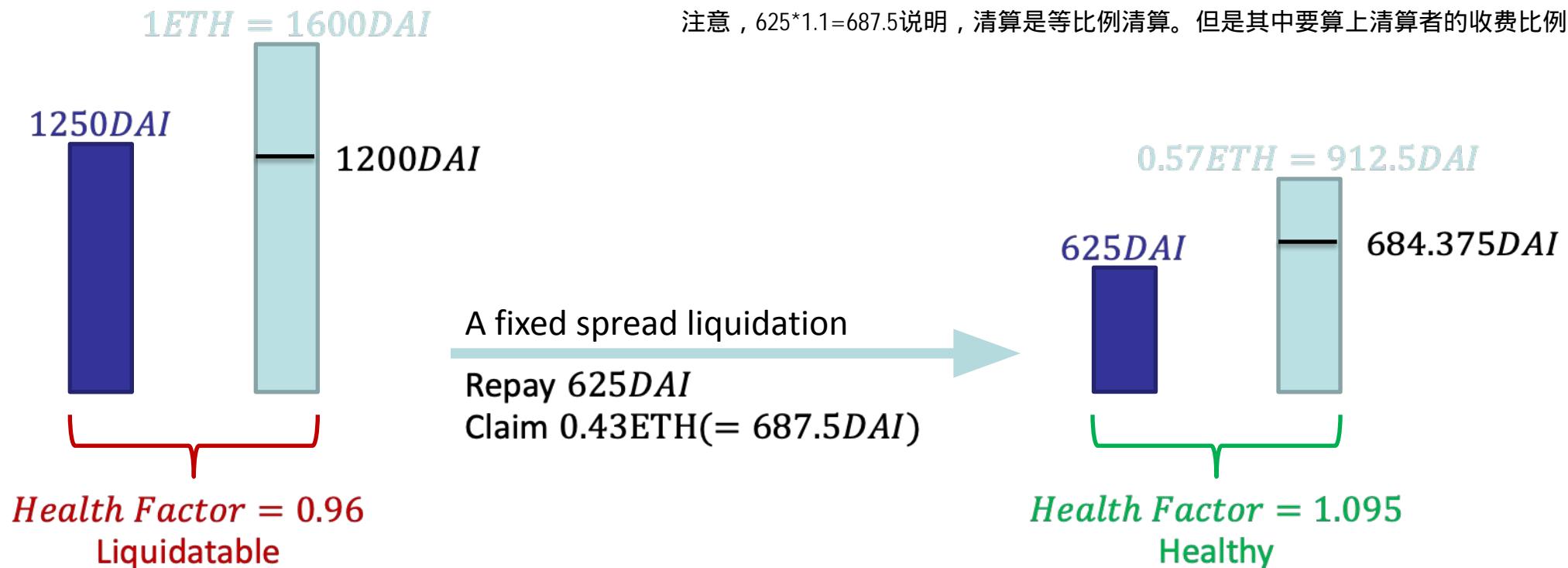
- Repays the debts of a borrowing position
- Acquires the collateral at a discounted price from the position in return
 - Typical discounts are e.g., 5-15% in Aave

Fixed Spread Liquidation

Debt — Borrowing Capacity
Collateral $Liquidation Threshold = 0.75$

Close Factor = 0.5

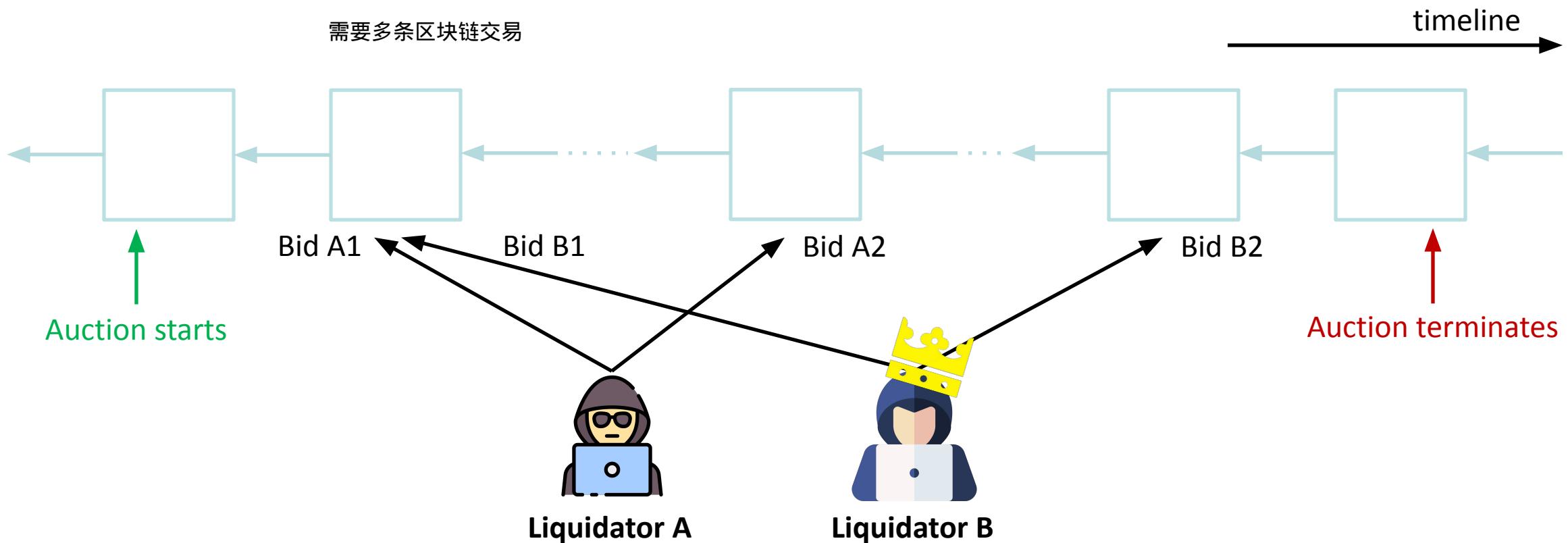
Liquidation Spread = 0.1



Auction Liquidation

拍卖清算

- Various liquidators bid over time until the auction terminates
- Requires multiple blockchain transactions.



Auction Liquidation

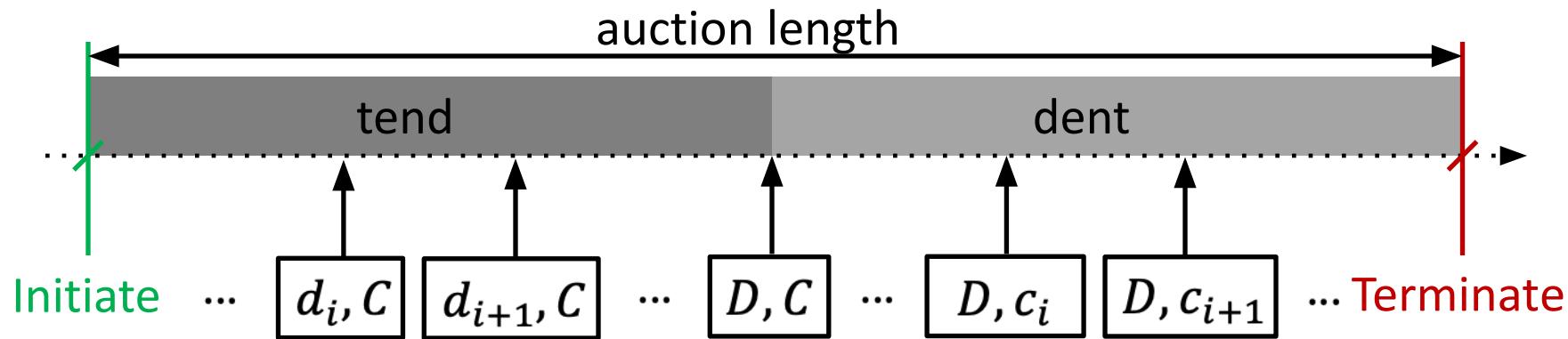
- English Auction
 - bidders outbid each other increasingly
- Dutch Auction
 - auction begins with a high asking price and the price lowers until the auction terminates

Auction Liquidation

MakerDAO tend-dent English auction (Day one – April 2021)

- A position with D debt and C collateral

具体拍卖过程可以看看GPT



$$d_{i+1} > d_i$$

$$c_{i+1} < c_i$$

Bid — debt to repay, collateral to claim

Auction Liquidation

MakerDAO Dutch auction (April 2021 – Present)

- **Instant Settlement**

- Unlike English auction which are operated in multiple transactions, the MakerDAO Dutch auction is settled instantly in one atomic transaction.



- **Flash Lending of Collateral**

- No upfront DAI (i.e., the debt) is required (i.e., a flash loan used ^{預付} specifically for MakerDAO liquidations).



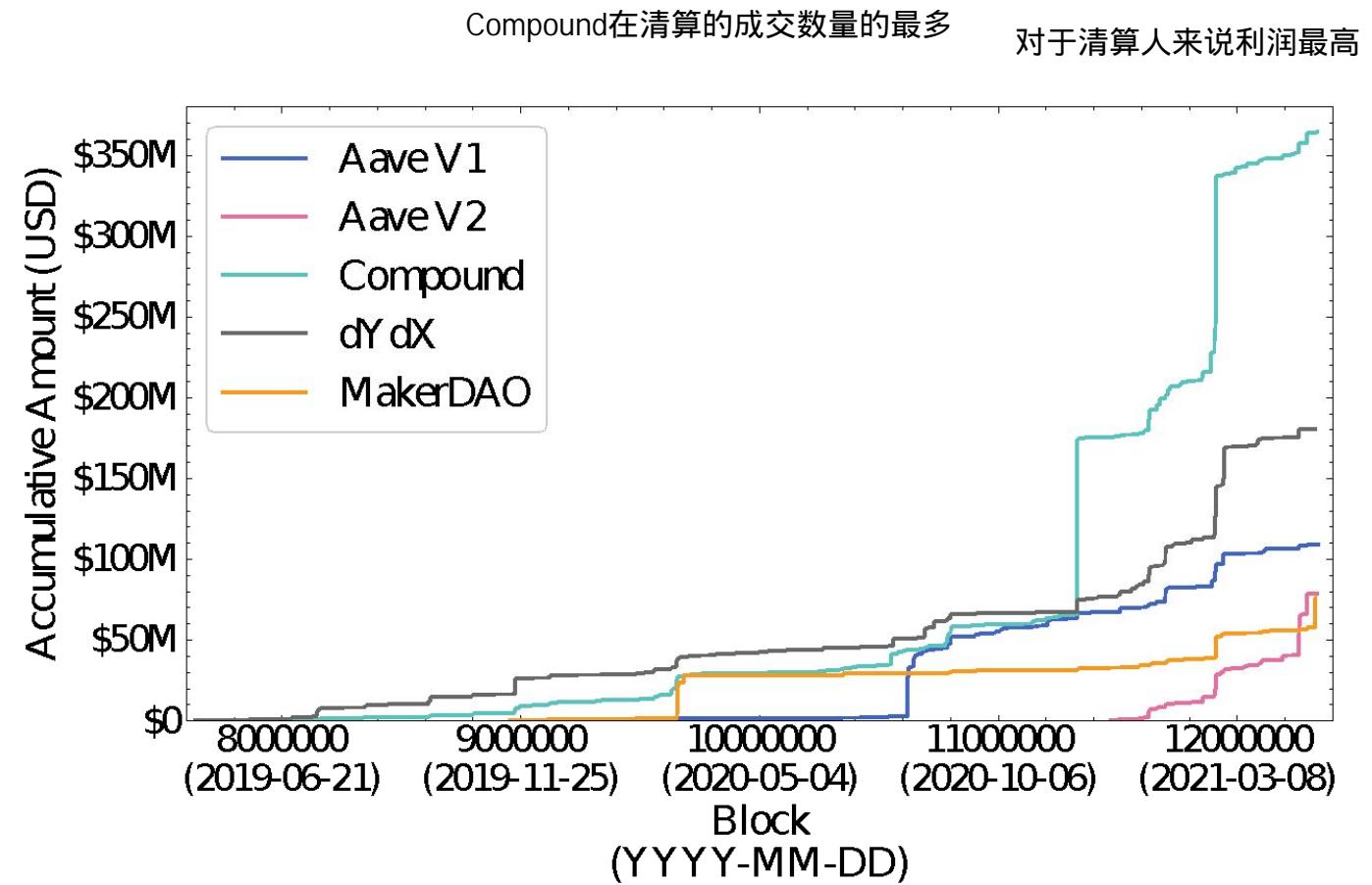
- **Price as a Function of Time**

- Collateral price decreases over time □ nobody can get the collateral for free by accident



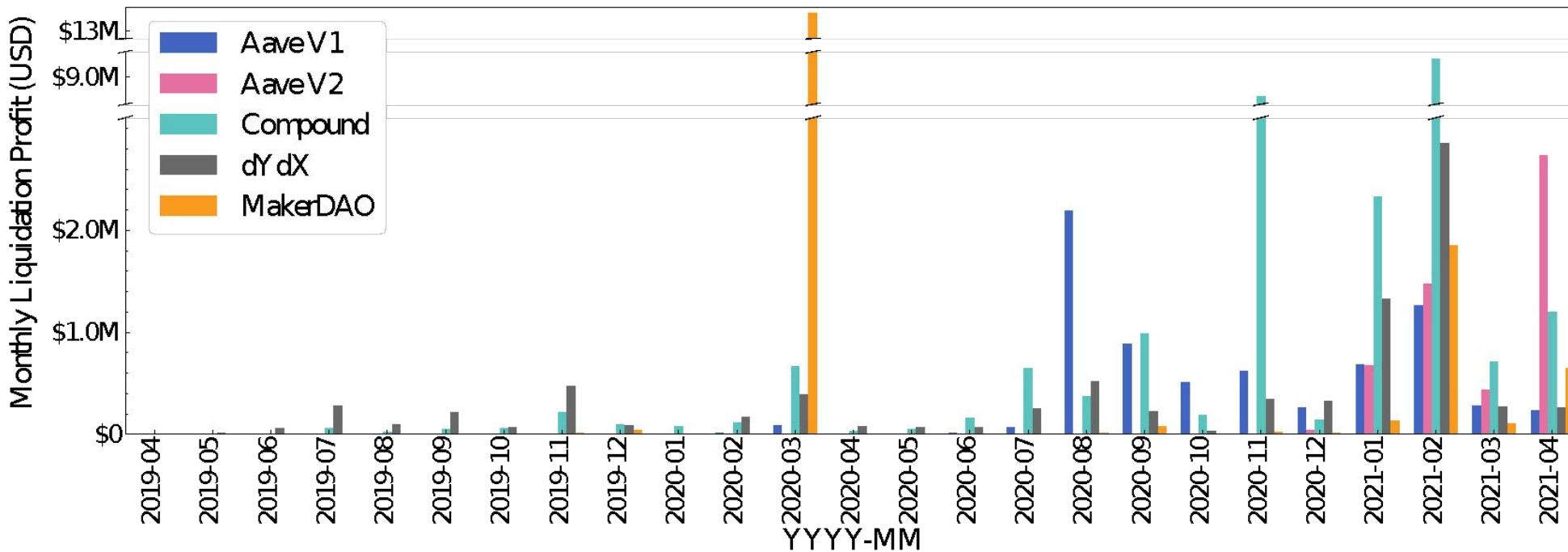
Liquidation Statistics

- April 2019 - April 2021 (2 years)
- Aave (V1 & V2), Compound, dYdX, and MakerDAO
- 28138 successful liquidations
- 807.46M USD of collateral sold through liquidations



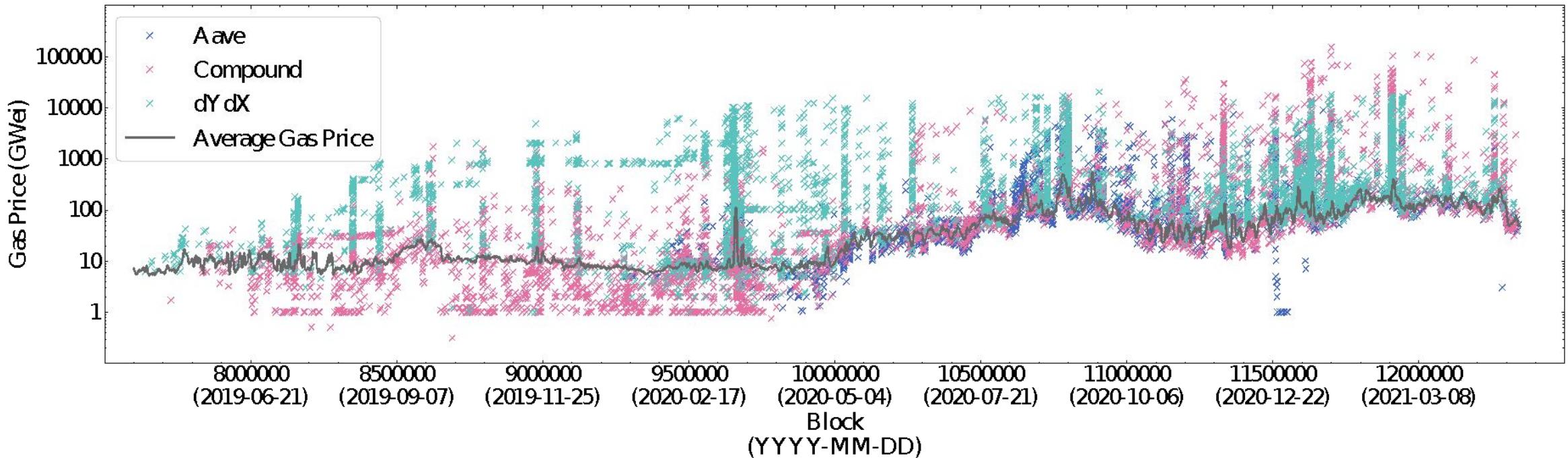
Liquidation Statistics

- Total profit: 63.59M USD
- MakerDAO outlier in March 2020, caused by bot failure.



Liquidation Statistics

- Liquidators typically pay significant gas fees, indicating severe competition.

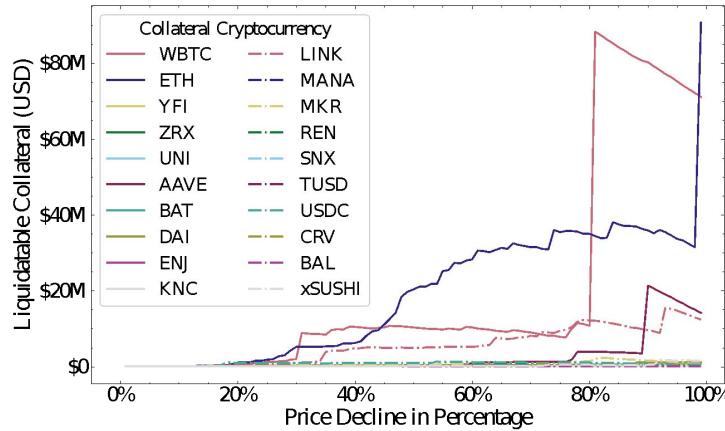


Liquidation Statistics

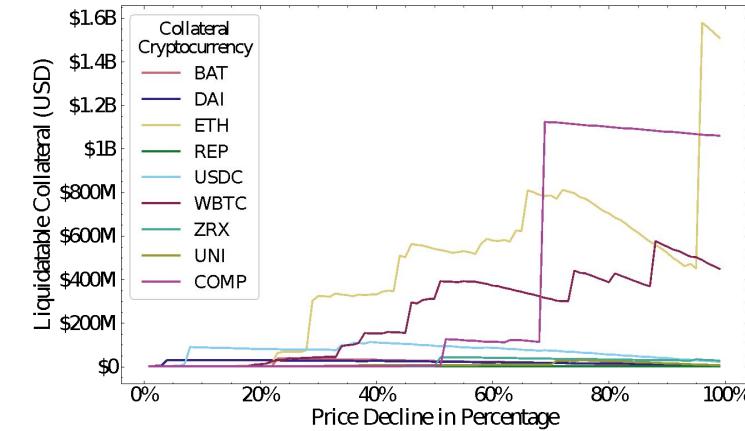
■ Liquidation Sensitivity

- liquidated collateral upon a hypothetical price decline.

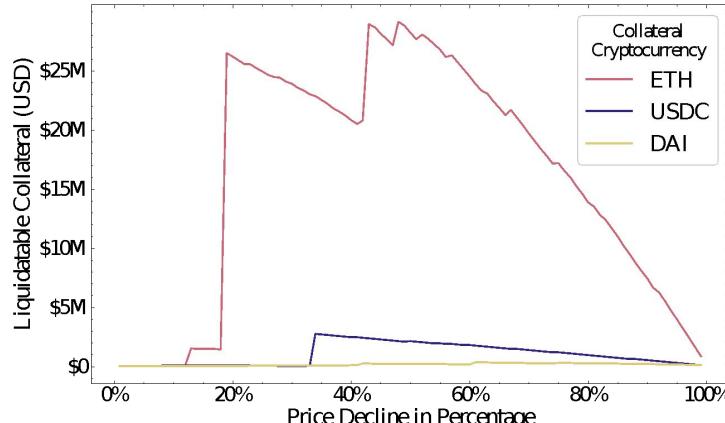
Aave



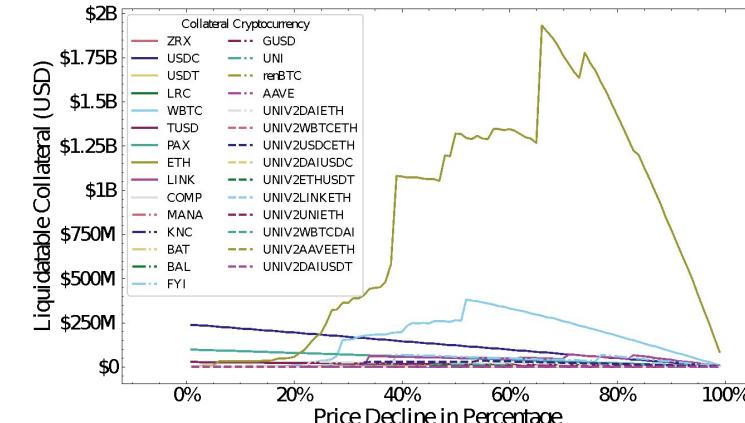
Compound



dYdX



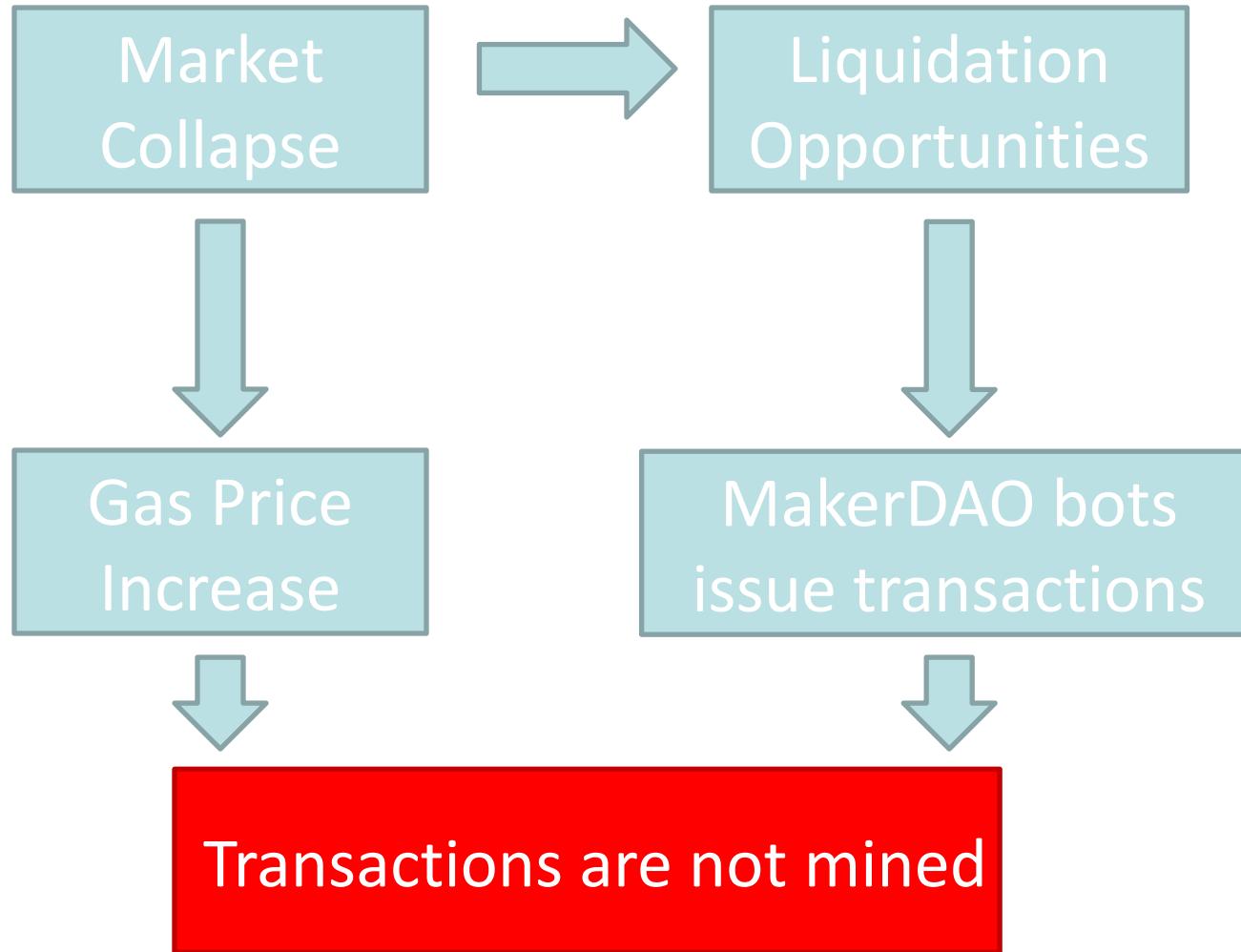
MakerDAO





Liquidation Case Study & Insights

Maker DAO Bot Failure



**Black Thursday for MakerDAO:
\$8.32 million was liquidated for
0 DAI**

whiterabbit Mar 15, 2020 · 6 min read



Photo by [slon_pics](#) on Pixabay

TL;DR

- Maker DAO liquidations on March 12 and 13 resulted in protocol losses of **5.67 million DAI**
- This happened due to the opportunity to win liquidation auctions with zero bids, which was **36%** of all liquidations
- The greatest Vault has lost ~35 000 ETH whereas the most successful liquidator has had a profit of **30 000 ETH**
- **\$8.32 million** was withdrawn through zero bids auctions in total

Liquidation Insights

■ Health Factor

- A fixed spread liquidation does not necessarily increase the health factor

■ Over-liquidation

- Liquidations sell excessive amounts of borrower's collateral

■ Optimal Liquidation strategy

- Liquidating up to the close factor is not necessarily the best strategy.
- Instead, two successive liquidations might offer more profits. 

通过最佳固定价差清算算法来执行获取到最好的清算策略

Optimal Fixed Spread Liquidation Algorithm

Input : A liquidatable position $\mathcal{POS} = \langle C, D \rangle$, where C represents the collateral value, while D represents the debt value; Liquidation threshold LT; Liquidation spread LS; Close factor CF.

Output: Amount of debt to repay in the two optimal successive liquidations, $repay_1$ and $repay_2$.

Function Liquidatable(\mathcal{POS}):

 | return $\frac{\mathcal{POS}.C \times LT}{\mathcal{POS}.D} > 1$;

end

Function Liquidate($\mathcal{POS}, repay$):

 | $\mathcal{POS}' \leftarrow \langle C - repay \times (1 + LS), D - repay \rangle$;
 | return \mathcal{POS}' ;

end

$repay_1 \leftarrow \text{argmax}_r \text{Liquidatable}(\text{Liquidate}(\mathcal{POS}, r))$;

$\mathcal{POS}' \leftarrow \text{Liquidate}(\mathcal{POS}, repay_1)$;

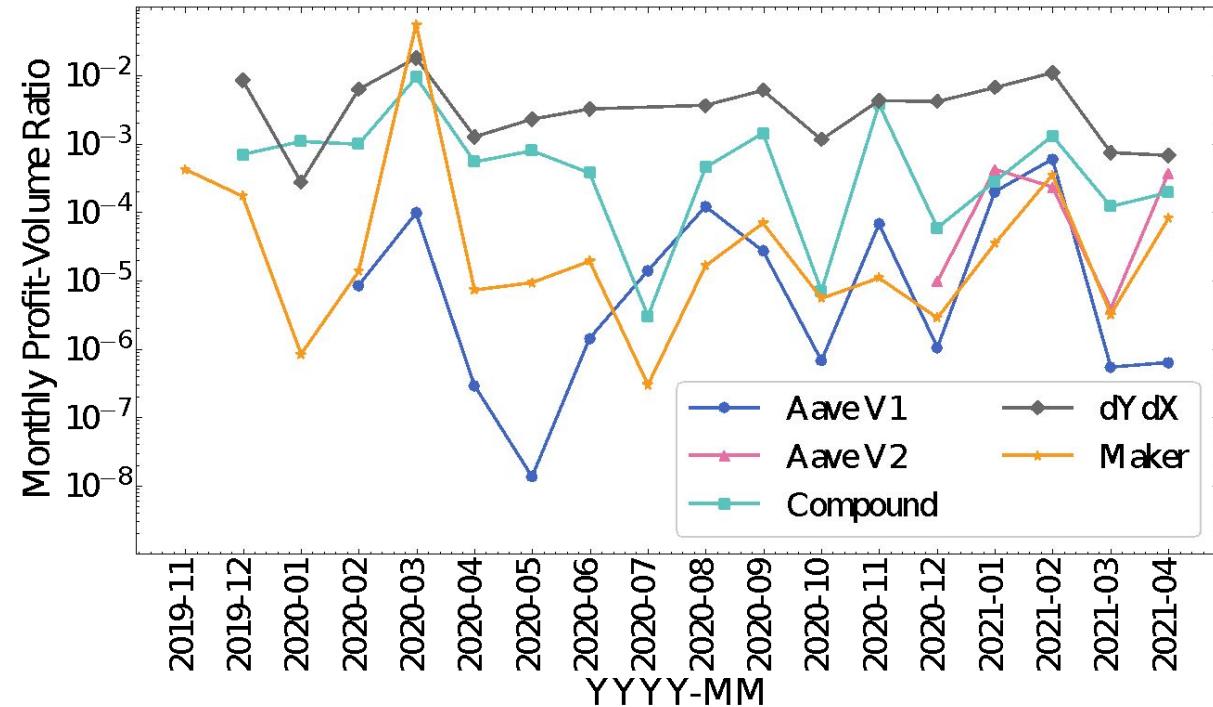
$repay_2 \leftarrow \mathcal{POS}' . D \times CF$;

Liquidation Insights

Comparison of liquidation mechanisms

- **Metrics:** the ratio between monthly liquidation profit and volume
- Data suggests that auction liquidations might be more borrower friendly
- dYdX does not have a close factor

dYdX没有关闭因子

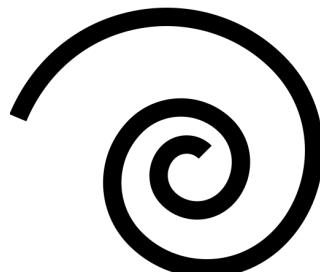
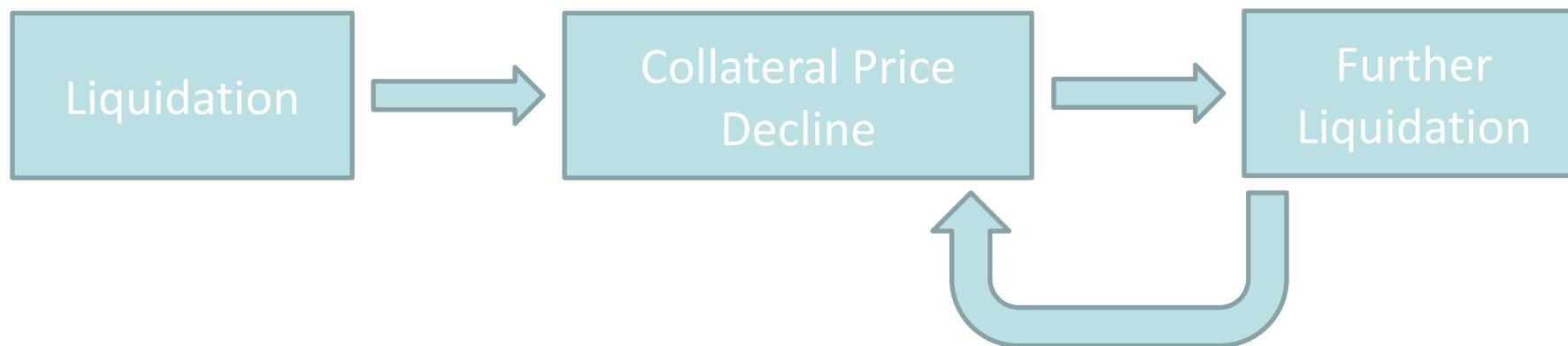


这些清算实际上都是科学家做的，他们大概率都不是人啦。不是普通人的赛道喽，成本和难度都很高

Liquidation Insights

- Deleveraging Spiral

就像价格下降的死亡螺旋



Is liquidation a good solution to secure lending pools?

Case Study: Optimal Fixed Spread Liquidation

- Compound
- November 26, 2020
- $LT = 0.75$

Token	Collateral	Debt	Price (USD)	
			Block 11333036	After price update
DAI	108.51M	93.22M	1.08	1.095299
USDC	17.88M	506.64K	1	1
Total Collateral (USD)			135.07M	136.73M
Borrowing Capacity (USD)			101.30M	102.55M
Total Debt (USD)			101.18M	102.61M

→

Healthy

Liquidatable

Case Study: Optimal Fixed Spread Liquidation

Original liquidation	Repay 46.14M USD
	Receive 49.83M DAI
	Profit 3.69M DAI
<hr/>	
Up-to-close-factor strategy	Repay 46.61 DAI
	Receive 50.34M DAI
	Profit 3.73M DAI
<hr/>	
Optimal strategy	Liquidation 1
	Repay 296.61K DAI
	Receive 320.34K DAI
<hr/>	
Liquidation 2	Repay 46.46M DAI
	Receive 50.18M DAI
<hr/>	
Profit 23.73K DAI	Profit 3.72M DAI

Optimal strategy yields 3.743M DAI instead of 3.69M DAI

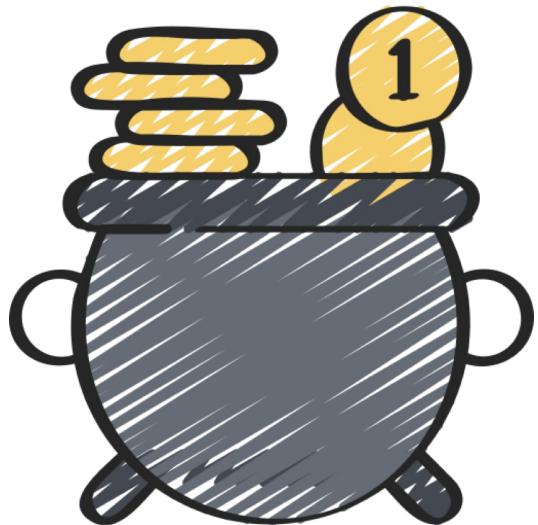
What ideas do you have to avoid liquidations?



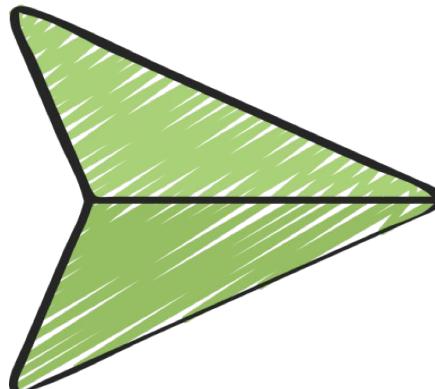
Flash Loans

What if Bart can grant a loan to Bob,
without the risk of Bob defaulting on the debt?

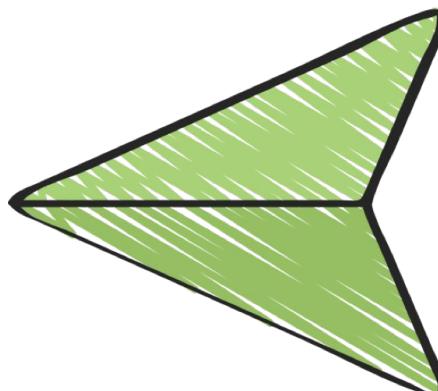
Flash Loan



1. Take flash loan

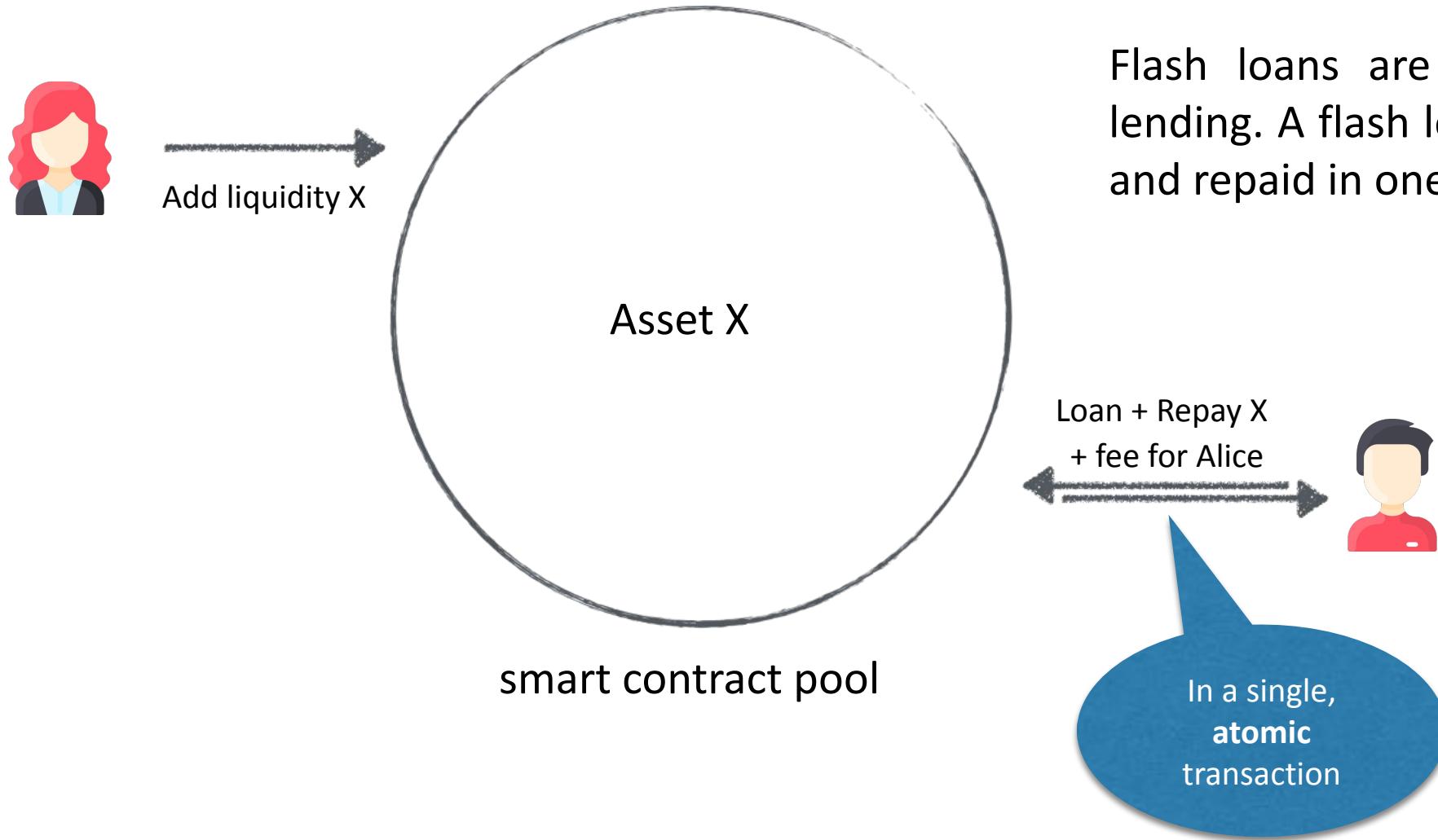


2. go-Wild(loan);



3. Repay loan + interest

Flash Loan

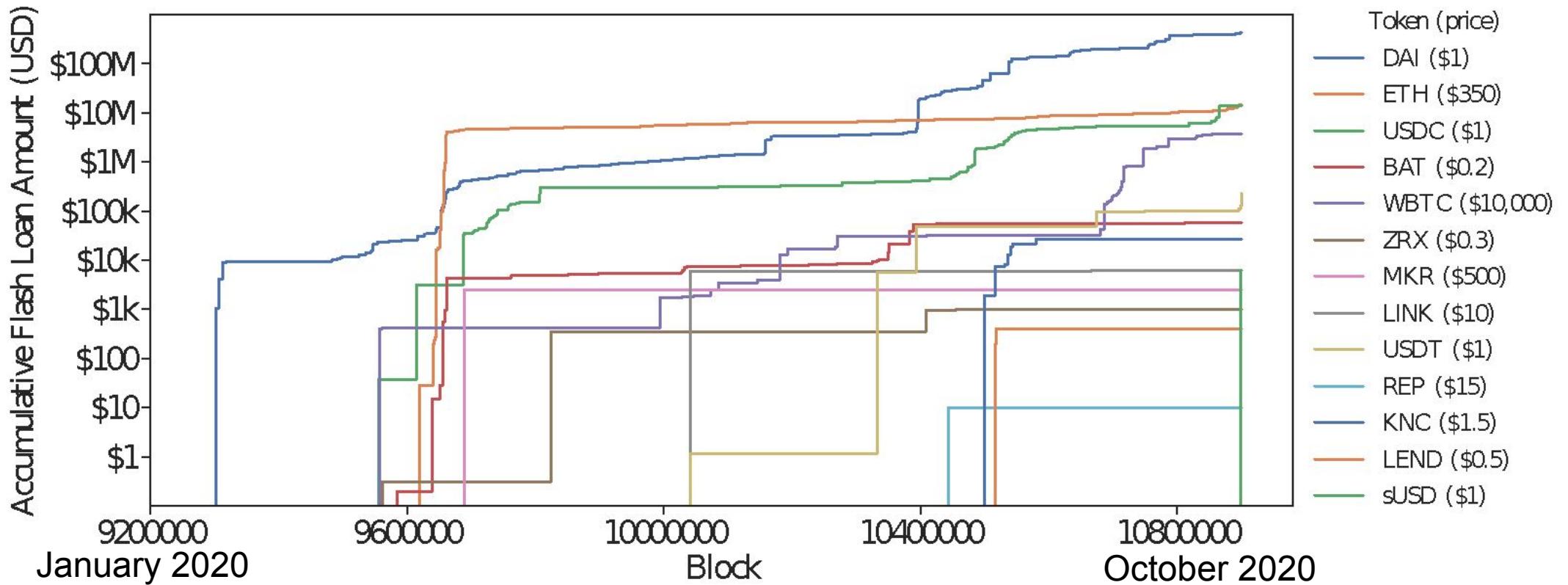


Flash loans are a special form of lending. A flash loan should be taken and repaid in one single transaction.

Flash Loan Pools

- Uniswap – 0.3% fees
 - V2 - 5B USD
 - V3 - 2.2B USD
- Aave – 0.3% fees
 - 10B USD
- dYdX – constant fee of 1 Wei
 - about 100M USD

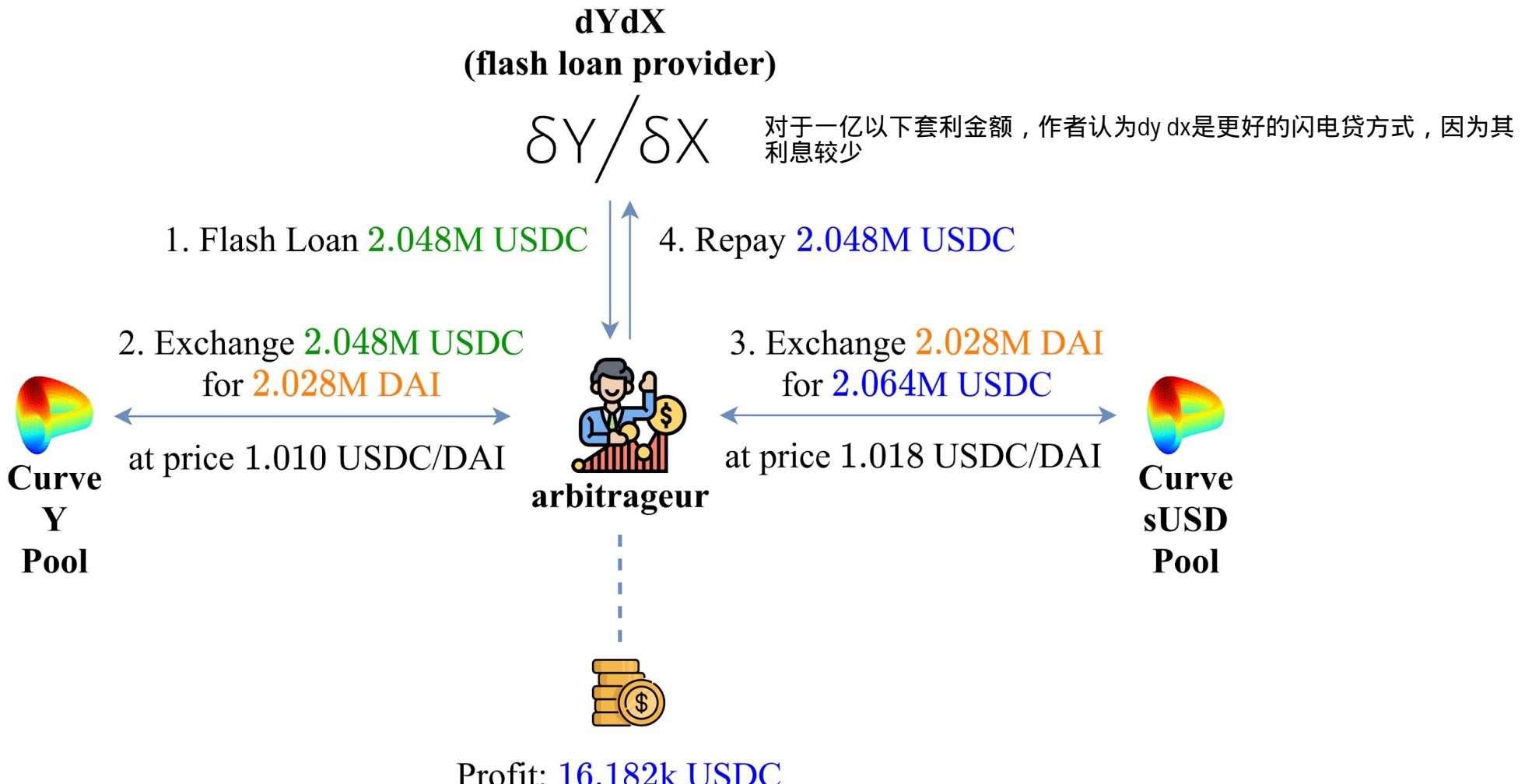
Flash Loan Sizes



Flash Loan Use Cases

- DeFi attacks
 - Price Oracle Manipulation
 - Pump and Dump
- (Risk-free) Arbitrage
- Washtrading 倒仓
- Flash Minting 闪铸
- Collateral swapping

Flash Loan Arbitrage

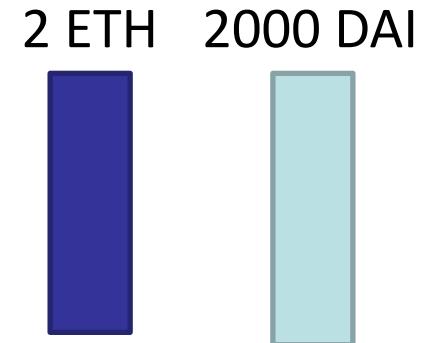
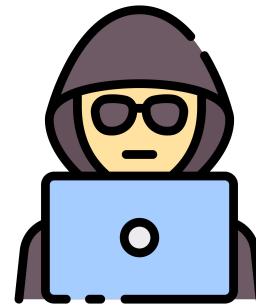


Flash Loan Based Liquidation

基于闪电贷的

- When a liquidator does not have the cryptocurrency upfront to repay
- Only works when the liquidation completes in one transaction

Given a liquidatable borrowing position with a debt of 2000 DAI collateralized by 2 ETH



Flash Loan Based Liquidation

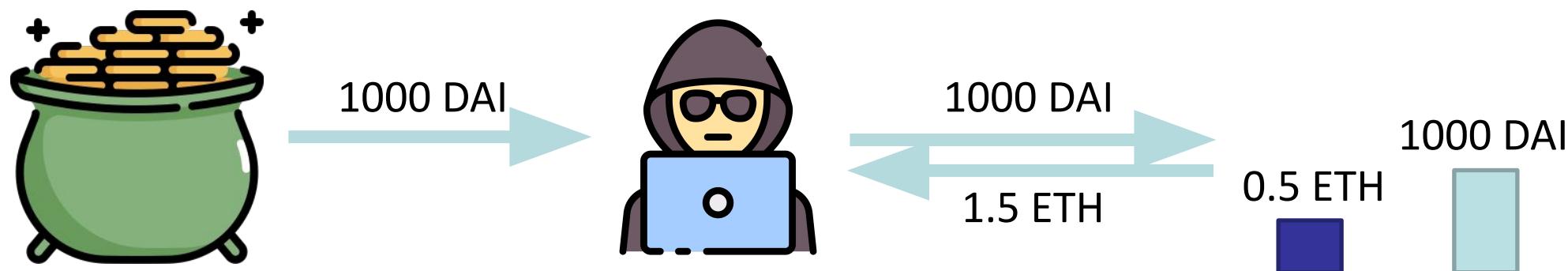
- When a liquidator does not have the cryptocurrency upfront to repay
- Only works when the liquidation completes in one transaction

Given a liquidatable borrowing position with a debt of 2000 DAI collateralized by 2 ETH

一个可清算的借款头寸，

债务为2000DAI

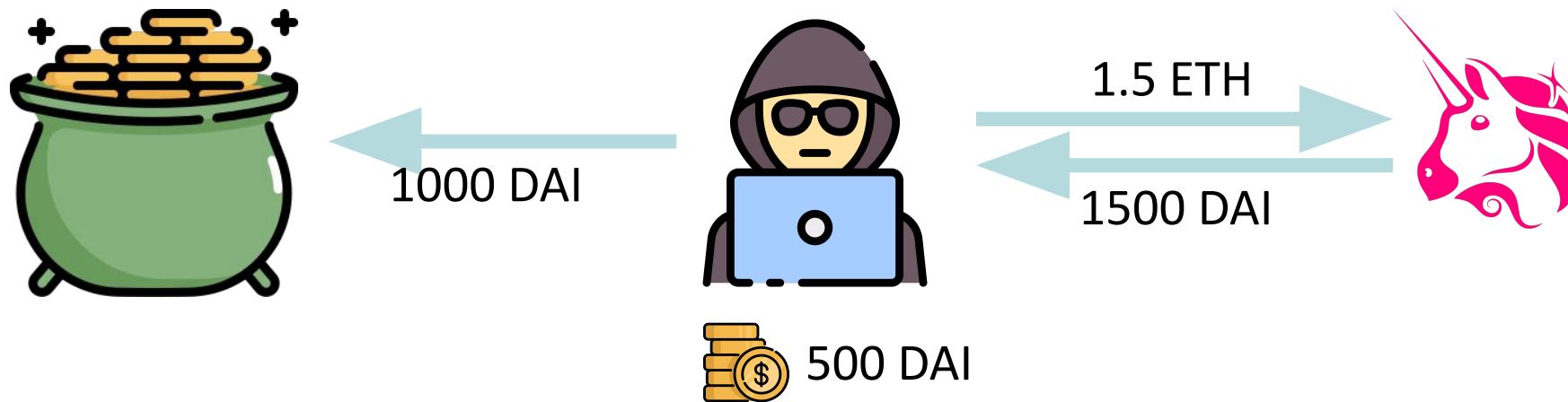
以2ETH为抵押



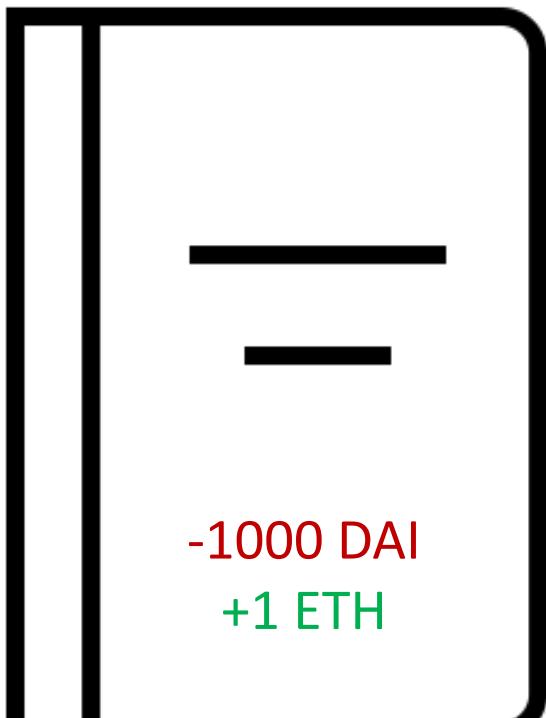
Flash Loan Based Liquidation

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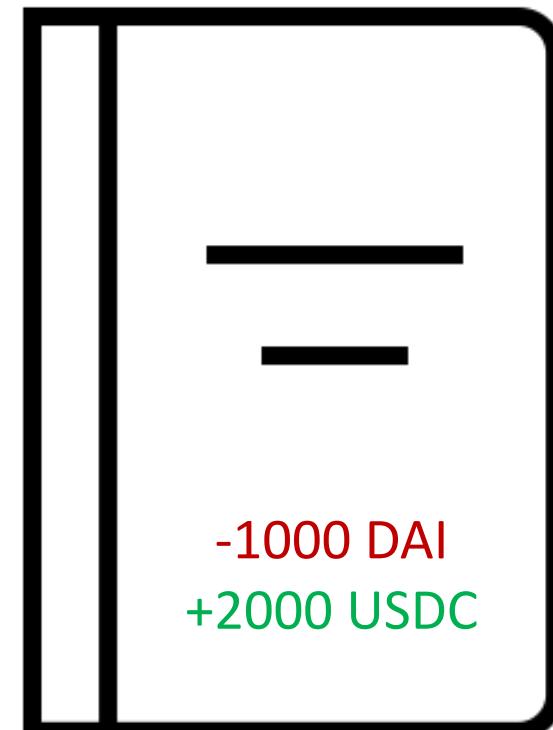


Collateral Swap



Dept Position

1. Take a flash loan of 1000 DAI
2. Repay 1000 DAI
3. Redeem 1 ETH
4. Swap 1 ETH to 2000 USDC
5. Collateralize 2000 USDC
6. Borrow 1000 DAI



Dept Position