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Decentralized lending and its users: Insights from Compound

2022 NYU Stern Fintech Conference
25 February 2022

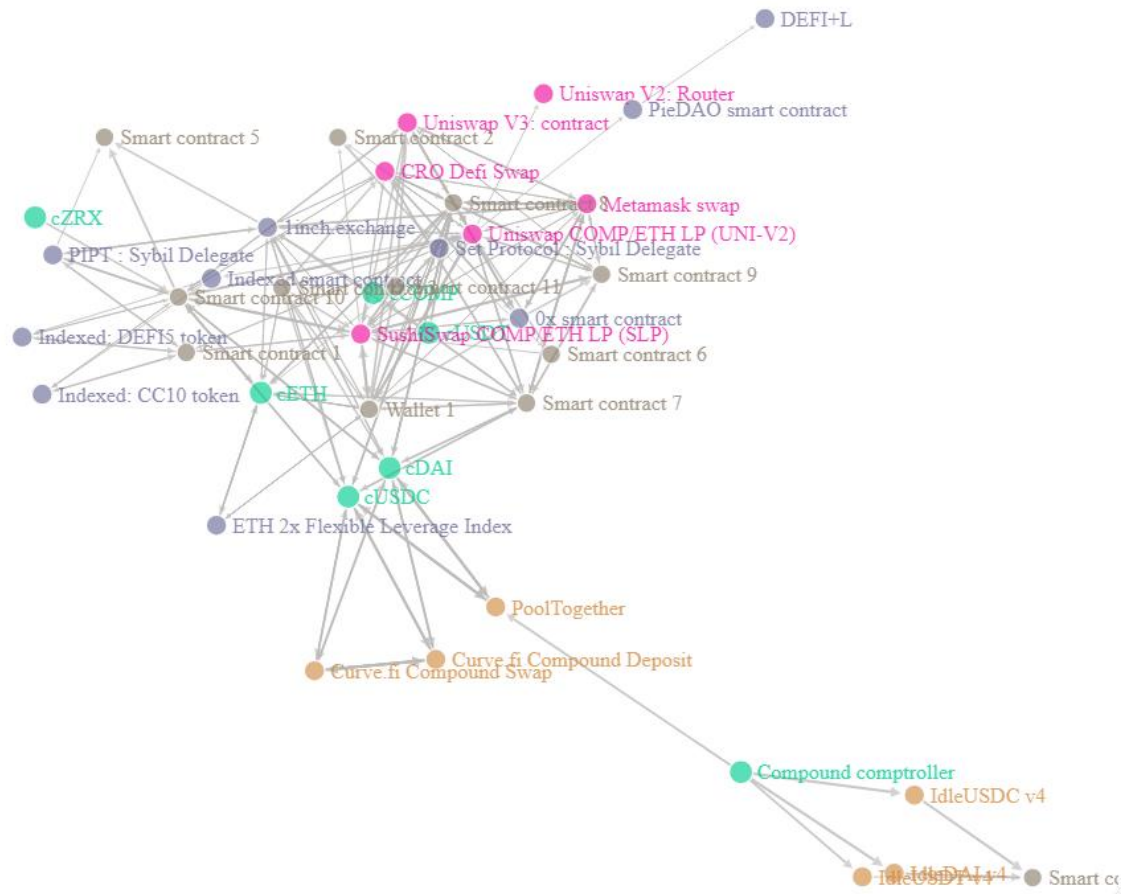
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Motivation

- Traditional lending model: credit allocation under information asymmetry (with frictions and agents and thus agency conflicts and behavioral biases).
- DeFi lending model: overcollateralized repo (swap with the option to swap back with algorithmically determined price); no information asymmetry and rule-based.
 - **Collateral-based only** (pseudonymity \rightarrow trustless exchange)
 - **No interim payments** (overcollateralization + **liquidation** to manage credit risk)
 - **Market-clearing interest rates**: e.g. $i_b = f(U)$ and $i_s = f(i_b, U, \lambda) \rightarrow$ **floating rates**
 - Various methods of paying interest on deposited collateral (if at all).
 - [ERC-20] tokens are numerical states on the blockchain. When computed (with off-chain data via oracles) by smart contracts, the output would give the desired economic outcomes.
 - Rule-based & no human interaction \rightarrow **self-restoring system based on users' incentives**
- Borrowing via DeFi protocols comes with many conditions, so who borrow?

An address contains several functions. A DeFi protocol may span several addresses. Compound's organization makes it easy to analyze.

- 1. Compound
- 2. DEX
- 3. Yield Agg
- 4. Others
- 5. Wallet



- Main addresses in Compound are **cToken addresses (lending pools)** and **Compound comptroller (reward distribution)**.
- Other contracts can choose to take the tokens issued by other addresses as inputs for further mathematical computations.
 - Decentralized exchanges (DEX)
 - Lending pools
 - Asset management: passive indices, yield aggregators and lotteries
 - Derivatives
 - *Smart contract bots*

Protocols often issue governance/native tokens as incentive to participate, since DeFi protocols rely on **user-provided liquidity** (peer-to-pool). Many names for this phenomenon, e.g. liquidity mining/yield farming reward.

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Token emission is coded as quantities and quoted as rates (APY).

Examples:

- For lending, incentive to supply (deposit) and borrow.
- For decentralized exchanges, incentive to supply tokens in liquidity pools to make market.
- Generally, protocols want users to stay (**lock, stake**) and interact.
- Tradable native tokens (ERC-20 token that can be issued by address owner) may be imbued with rights such as cash flows or voting, or nothing at all.

Literature review

- Bartoletti et al. (2021), Castro-Iragorri et al. (2022), Gudgeon et al. (2020): different interest rate models for DeFi lending protocols, financial intermediation and risk
- Kozhan and Viswanath-Natraj (2021), Mayer and Li (2021) and Saengchote (2021): MakerDAO and DAI; stablecoin / loan intersection
- Perez et al. (2020): Compound liquidation mechanism
- Mayer (2021): governance tokens
- Mayer et al. (JFE, forthcoming): security features of tokens and staking

**This paper: Who are Compound's borrowers and why do they borrow?
How important is liquidity mining incentive to Compound?**

1. Does liquidity mining reward affect net deposits? [Not really]
2. Does liquidity mining reward affect loan demand? [Mostly yes]

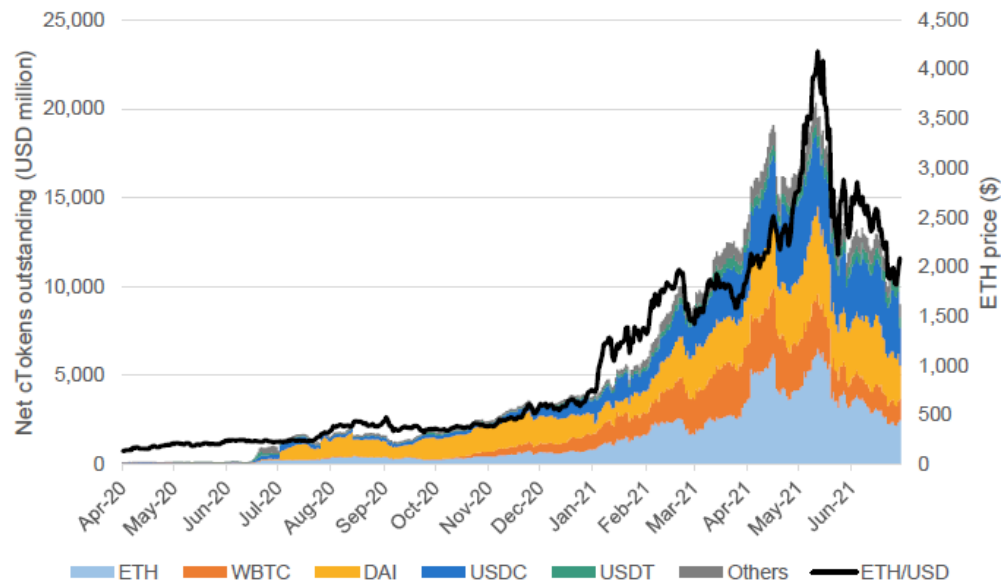
Data sources: Ethereum blockchain data from Google BigQuery + Compound's data API

- Compound's transactions between May 2019 and June 2021.
~8 million deposits, 3.56 million redemptions, 0.16 million borrows, 0.13 million repayments, 356,800 unique addresses
- Manual inspection of 100 top targets (to) and sources (from) of all related token transfers using Etherscan.io to identify types of addresses.
- Addresses are divided in to 7 categories: (1) large wallets, (2) small wallets, (3) yield aggregator, (4) on-ramps, (5) decentralized exchanges, (6) asset management, (7) untagged [unidentified] smart contracts.
- Tokens transfers to cToken addresses are aggregated **daily** at midnight UTC.
- Rates are obtained via Compound's data API.

Some facts about Compound

- Top 100 depositors account for 75%. Top 100 borrowers account for 78%.
- Interest rate model is one key equation (the other is account liquidity), and its main input variable is utilization (borrow/supply) → floating rate.

Panel A: Daily net cToken outstanding in USD million



Deposits

DAI+USDC+USDT ~50%
+ETH+WBTC ~92%

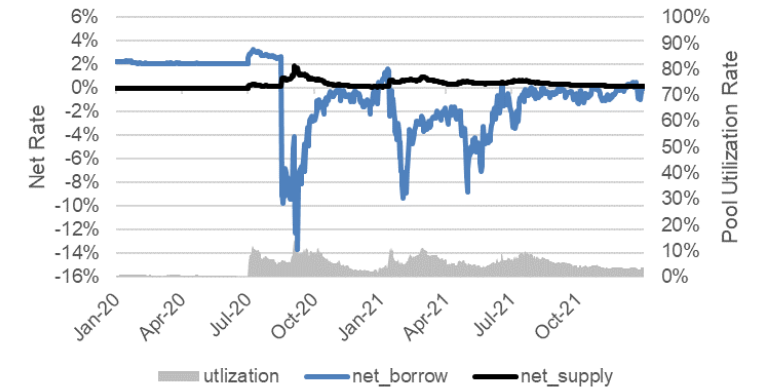
Loans

DAI+USDC+USDT ~88.7%

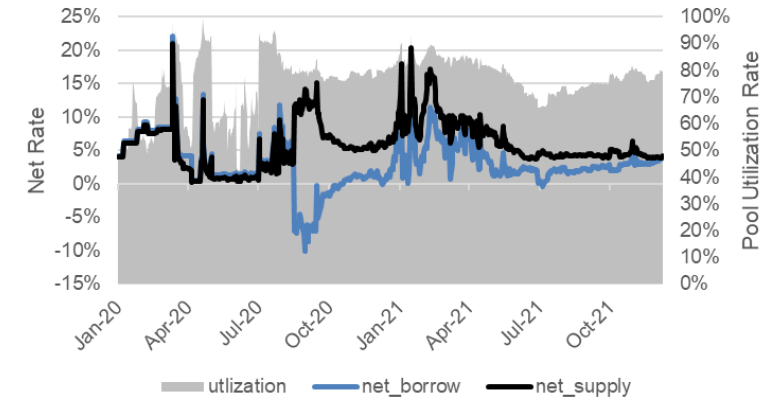
Low utilization → negative net borrow rate (e.g. ETH)

USDT is not very popular (compared to USDC, DAI)

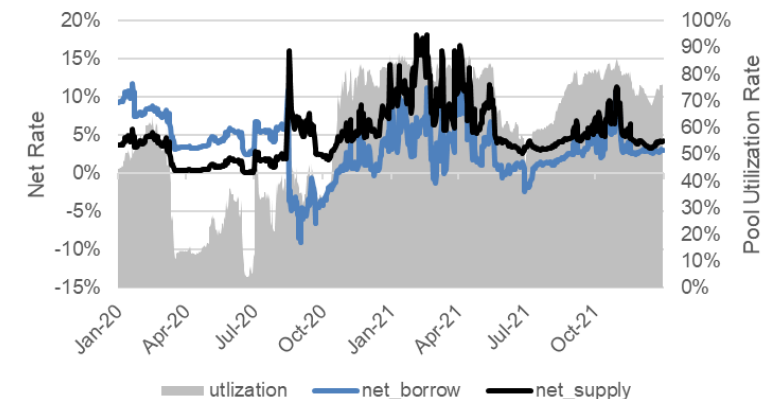
ETH: Jan 2020 - Dec 2021



DAI: Jan 2020 - Dec 2021



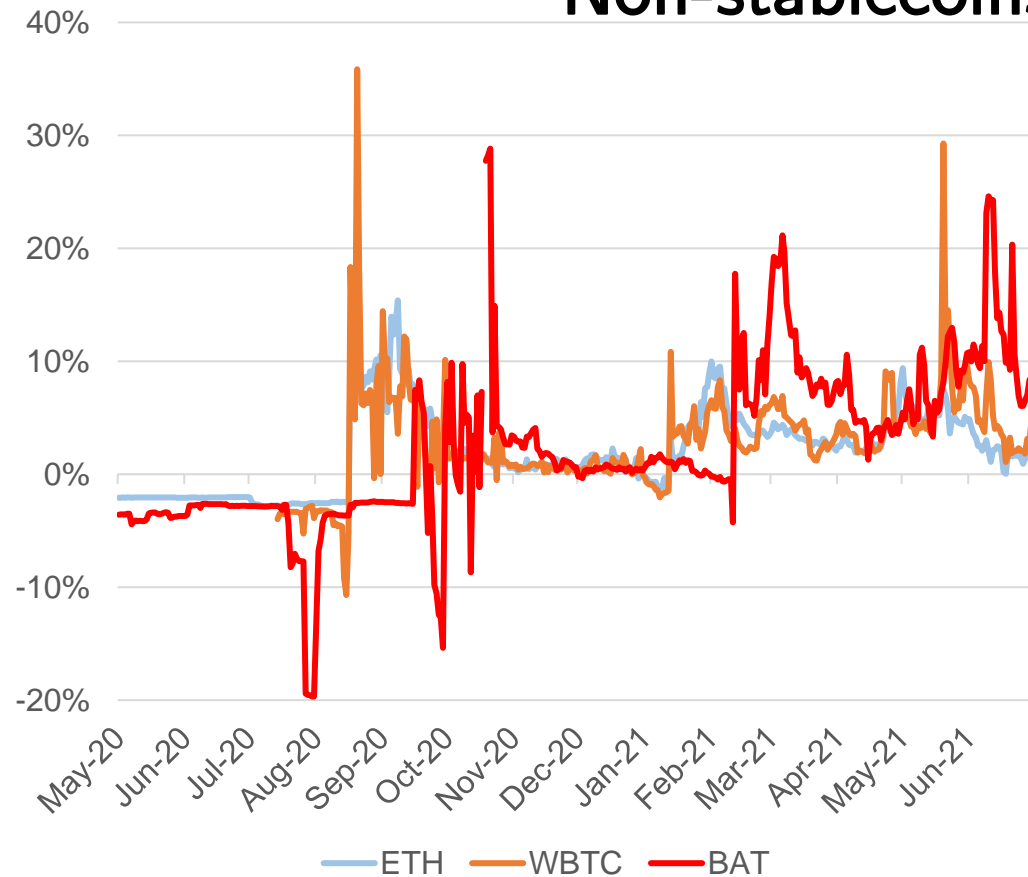
USDC: Jan 2020 - Dec 2021



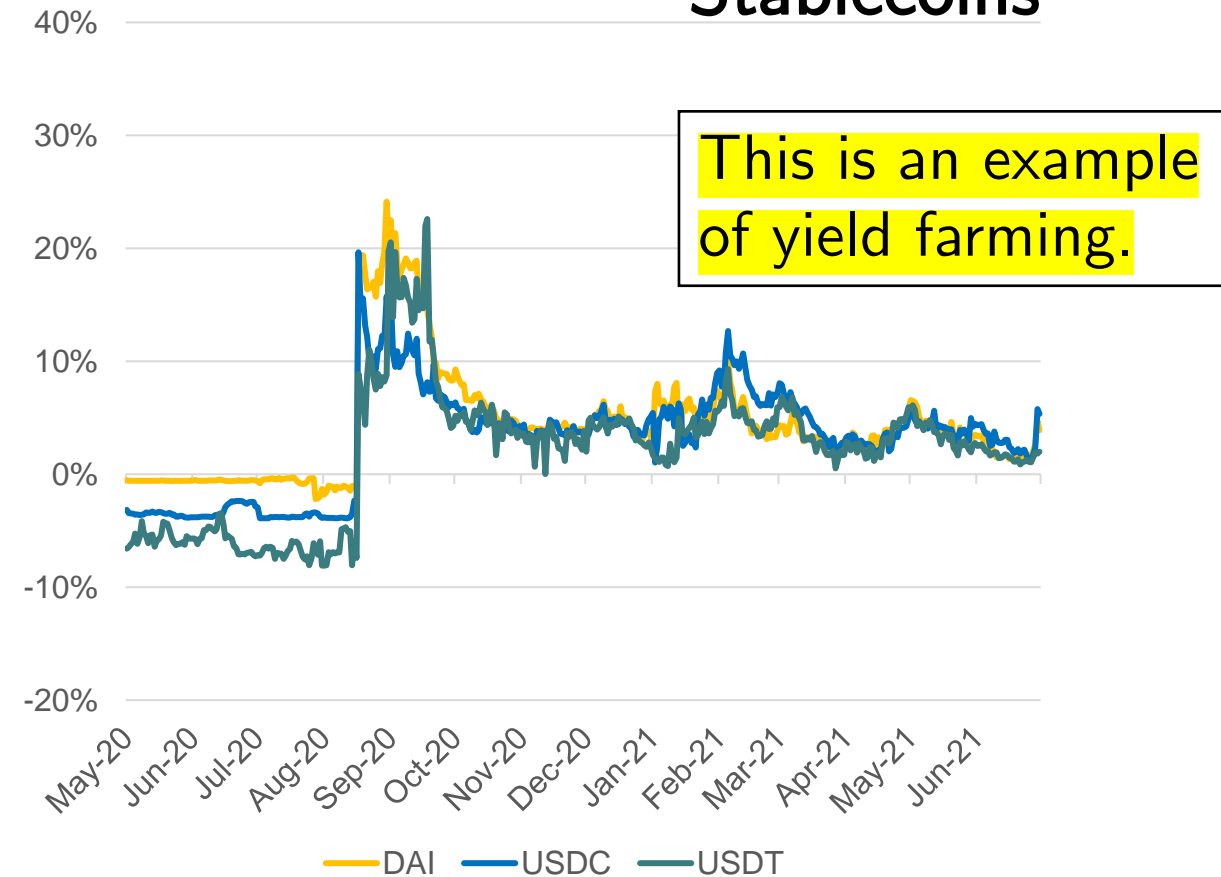
Profit to “carry trade” (long-short strategy on the same token so there is no collateral basis risk hence no liquidation risk).

The spread comes from COMP distribution, so there is still some risk.

Non-stablecoins



Stablecoins



Macro-view: Do rates matter for aggregate activity?

1. Does liquidity mining reward affect net deposits (net cToken minting)?

$$NetFlow_{k,t} = \alpha_k + \beta_{1,k}SupplyRate_{k,t-1} + \beta_{2,k}SupplyReward_{k,t-1} + \beta_{3,k}NetDAI_t + \gamma_k X_t + \varepsilon_{k,t}$$

Not really! But net DAI minted is strongly correlated with net cDAI minted.

(In early 2021, ~15% of outstanding DAI was held in cDAI. It's ~9% now.)

2. Does liquidity mining reward affect loan demand?

$$\log(Loan_{k,t}) = \alpha_k + \beta_{1,k}BorrowRate_{k,t-1} + \beta_{2,k}BorrowReward_{k,t-1} + \gamma_k X_t + \varepsilon_{k,t}$$

True for 7 out of 10 tokens that receive COMP distribution.

Micro-view: Who are Compound's borrowers?

Panel B: Borrowers.

	Unique addresses	Stablecoin loans (num)	Crypto loans (num)	All token loans (num)	Stablecoin loans (USD mn)	Crypto loans (USD mn)	All tokens (USD mn)
Large wallet	217	1,441	614	2,055	28,659.5	3,762.6	32,422.1
Small wallet	21,986	32,220	12,230	44,450	8,164.3	1,912.9	10,077.2
Yield aggregator	8	55	60	115	4,224.7	145.9	4,370.6
On-ramp access	24	4,062	973	5,035	2,026.6	425.6	2,452.2
Decentralized exch.	1	7		7	3.8		3.8
Asset management	2	2		2	256.6		256.6
Uninden. contracts	51	796	310	1,106	11,345.3	514.8	11,860.0
All	22,289	38,583	14,187	52,770	54,680.7	6,761.9	61,442.6

	Average value of loan (US mn)			Average loan duration (days)		
	Stable	Crypto	All	Stable	Volatile	All
Large wallet	19.89	6.13	15.78	23.6	15.2	21.1
Small wallet	0.25	0.16	0.23	40.6	26.6	36.7
Yield aggregator	76.81	2.43	38.01	2.4	2.9	2.7
On-ramp access	0.50	0.44	0.49	0.6	0.3	0.6
Decentralized exch.	0.54		0.54	0.0		0.0
Asset management	128.32		128.32	81.6		81.6
Uninden. contracts	14.25	1.66	10.72	9.0	6.5	8.3
All	1.42	0.48	1.16	33.8	23.2	31.0

Main groups (~95.6% of \$)

Large wallets

1% of addresses, 52.8% of \$
9.5 loans / address

Small wallets

98.6% of addresses, 16.4% of \$
2 loans / address
Longest average loan duration

Yield aggregators

0.04% of addresses, 7.1% of \$
14.38 loans / address
Shortest average loan duration

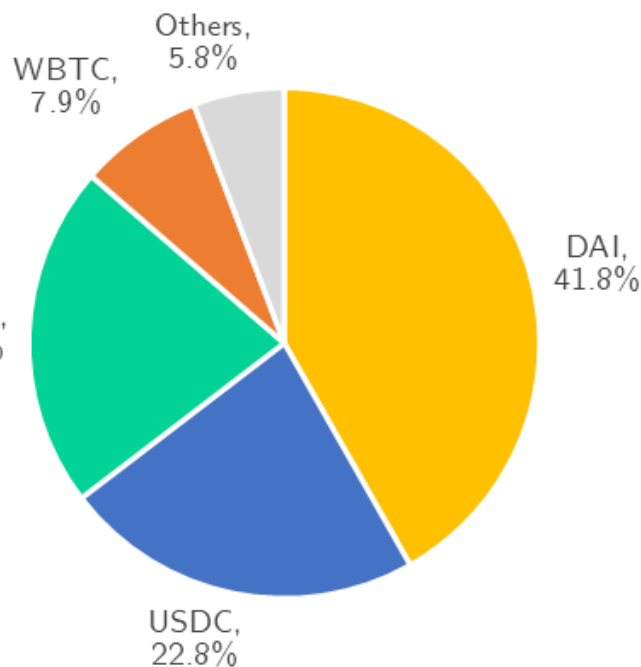
Smart contracts

0.2% of addresses, 19.3% of \$
21.69 loans / address

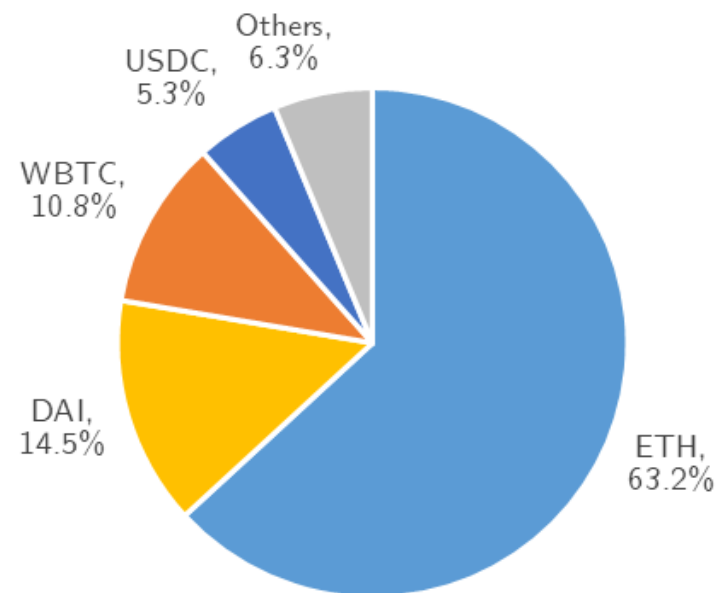
Liquidations do occur but are small because of ample overcollateralization.

- Liquidations occur during sharp price declines.
- Liquidation in 2021 are **~2% of outstanding loans**.

Denomination of liquidated loans

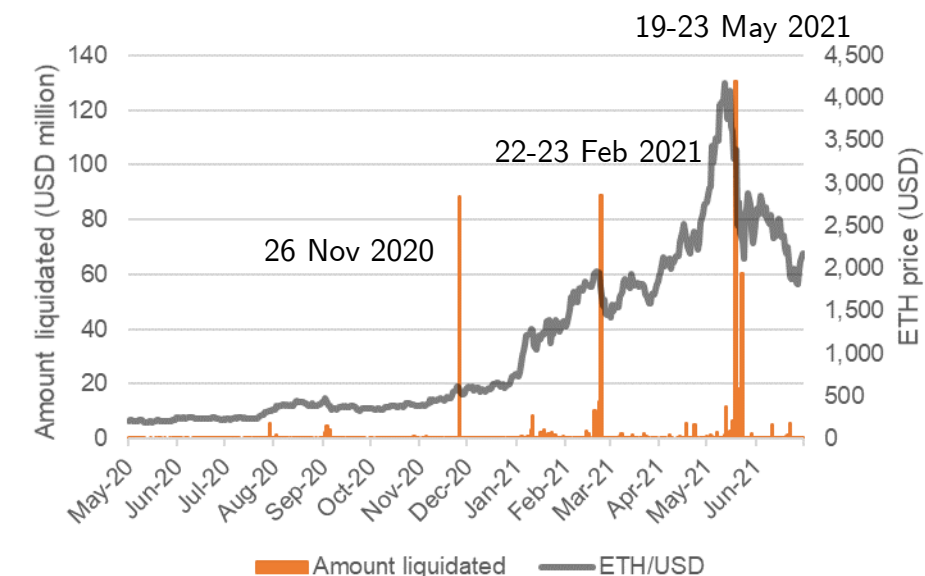


Collateral of liquidated loans

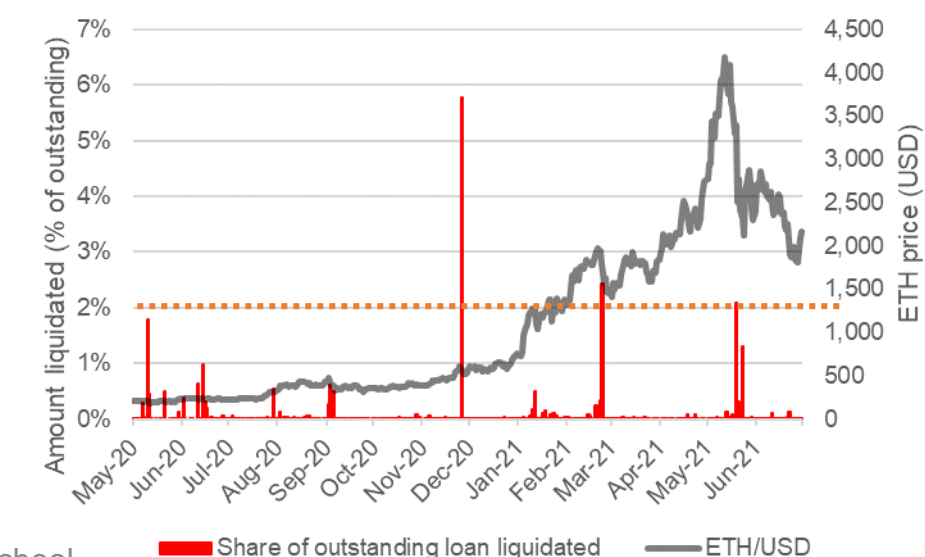


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Liquidations in USD million



Liquidations as % of outstanding protocol loans



What are borrowed tokens used for?

One case: redeposit into cToken contract to earn COMP (carry trade earlier)

~11% of loans (count, not value) are redeposited into Compound within 1 day.

More so for large wallets (whales?) and unidentified contracts (hedge funds?).

Panel B: Share of daily loans that are redeposited on the same day

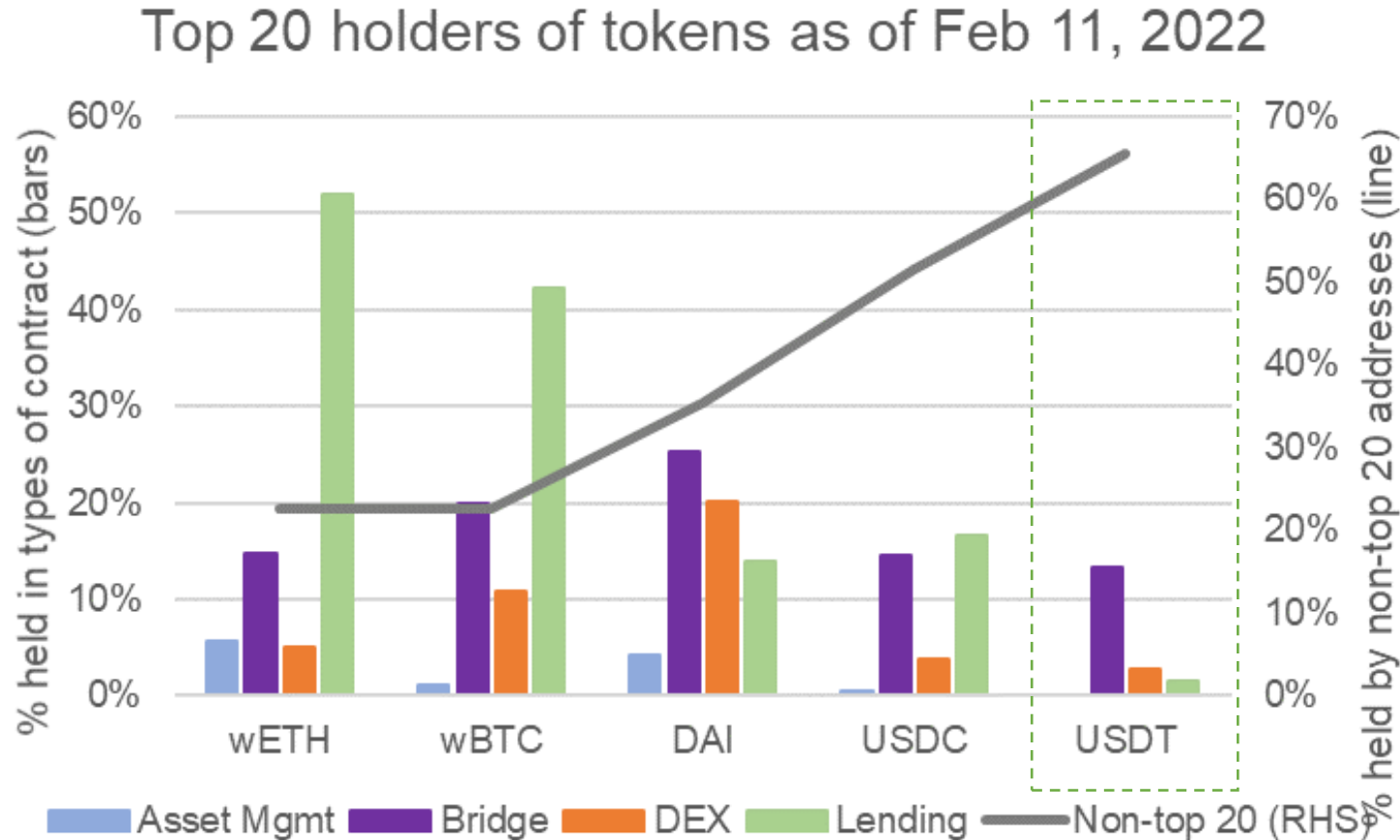
	cETH	cWBTC	cBAT	cCOMP	cLINK	cREP	cUNI	cZRX	cDAI	cUSDC	cUSDT	cTUSD	Total
Large wallet	13.5%	22.2%	49.6%	33.3%	40.0%	10.0%	13.9%	16.7%	14.3%	9.8%	1.2%	10.0%	12.1%
Small wallet	19.1%	10.5%	24.6%	17.0%	9.8%	4.3%	15.3%	8.4%	12.5%	6.0%	2.5%	0.3%	9.7%
Yield aggregator		97.3%							0.0%	0.0%	0.0%		72.0%
On-ramp access										0.0%			0.0%
Decentralized exchange									100.0%				100.0%
Asset management	12.5%	0.0%	23.8%			0.0%	0.0%	0.0%	55.8%	8.9%	0.0%		23.0%
Unidentified contracts	34.0%	20.5%	54.0%	0.0%	62.5%	52.6%	16.0%	12.5%	47.5%	42.8%	1.6%		39.1%
All	18.9%	12.9%	26.3%	18.3%	15.1%	6.7%	15.0%	8.8%	13.8%	6.8%	2.4%	0.6%	10.5%

Panel C: Share of daily loans that are redeposited within one day

	cETH	cWBTC	cBAT	cCOMP	cLINK	cREP	cUNI	cZRX	cDAI	cUSDC	cUSDT	cTUSD	Total
Large wallet	16.4%	24.0%	51.1%	33.3%	43.3%	20.0%	16.7%	25.0%	15.7%	10.8%	2.0%	10.0%	13.5%
Small wallet	20.7%	12.2%	26.8%	17.2%	10.7%	5.4%	16.1%	10.1%	13.3%	6.6%	3.0%	0.3%	10.5%
Yield aggregator		97.3%							0.0%	0.0%	0.0%		72.0%
On-ramp access										0.0%			0.0%
Decentralized exchange									100.0%				100.0%
Asset management	12.5%	0.0%	38.1%			0.0%	0.0%	0.0%	57.5%	11.6%	0.0%		25.2%
Unidentified contracts	34.0%	21.4%	58.0%	0.0%	62.5%	63.2%	16.0%	15.6%	48.9%	44.1%	3.2%		40.6%
All	20.6%	14.5%	28.5%	18.5%	16.3%	8.7%	15.9%	10.8%	14.7%	7.4%	2.9%	0.6%	11.4%

How can you use borrowed tokens in 2022?

(Also, the top 20 addresses hold a significant portion of many tokens!)



Top uses:

Non-stablecoins

1. Lending
2. Bridge
3. DEX

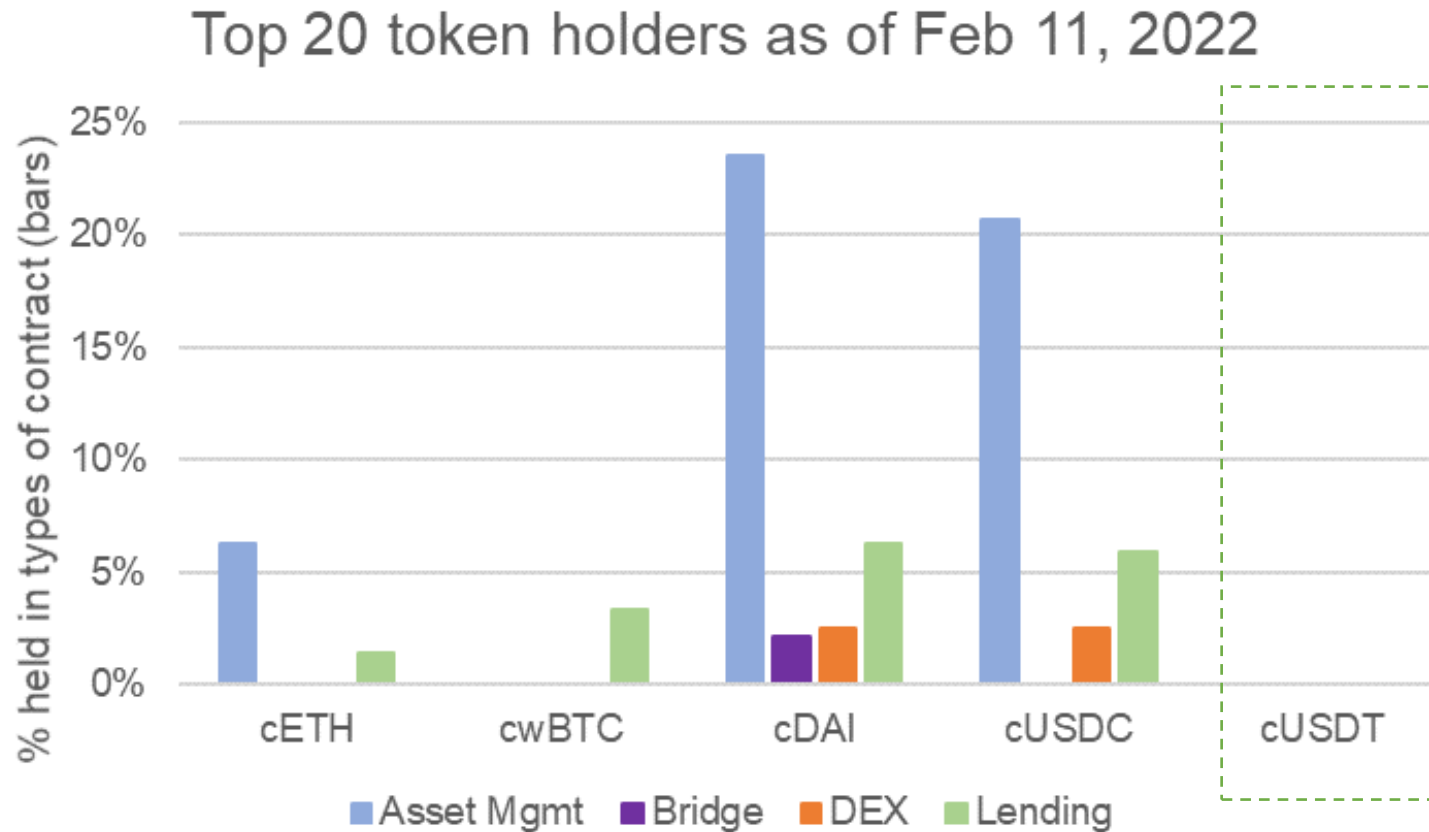
Stablecoins

1. Bridge
2. Lending
3. DEX

Source: Etherscan.io

How can you use deposited cTokens in 2022?

(...other than as collateral for Compound loans.)



Source: Etherscan.io

Asset Management/ Yield Aggregators

- Index Coop ETH 2x Flexible Leverage Index
- Yearn GenLevComp3
- Angle Generic Compound

DEX

- Curve.fi cDAI/cUSDC

Lending

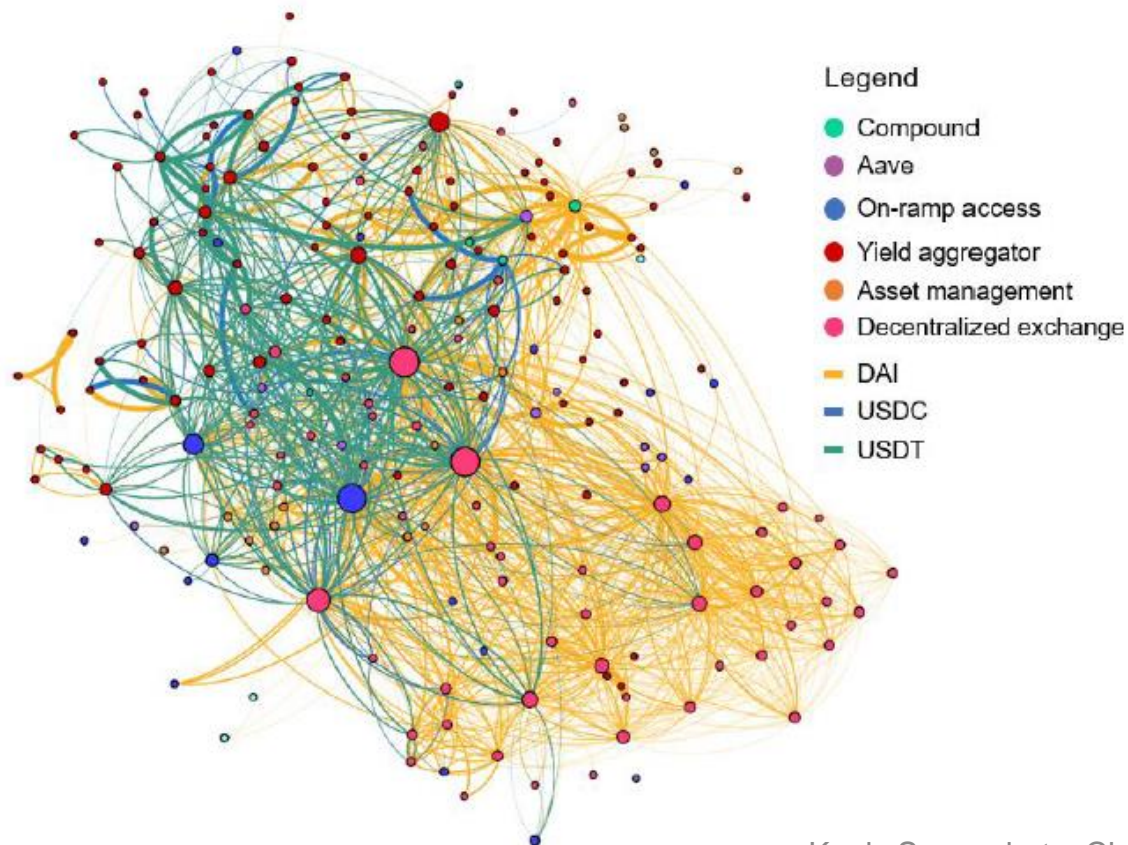
- Notional Finance

DeFi Leverage + Permissionless Composability → DeFi Systemic Risk?

DeFi is prone to inter-protocol (tacit/implicit) leverage. Liquidity mining reward tokens can also be staked as collateral for further (explicit) leverage.

Figure 6: Network diagram of DeFi stablecoins.

This figure plots the stablecoins (DAI, USDC and USDT) flows between smart contracts identified as part of Compound, Aave (a lending protocol), yield aggregator protocols, asset management protocols, decentralized exchange (DEX) protocols, on-ramp access points, and other smart contracts that exist between May 2019 and June 2021.



cDAI is Compound's liabilities

MakerDAO: ETH → DAI, then ...

Compound: DAI → cDAI, Aave: DAI → aDAI,

Yearn: DAI → yDAI, etc.

Curve accepts these **"depository receipts"** (liabilities)

cDAI/cUSDC → LP token (Curve's liabilities)

yDAI/yUSDC/yUSDT/yTUSD → LP token

All these count as total value locked (TVL) in DeFi, along with staked governance tokens (COMP, MKR, AAVE, CRV, CVX, YFI, etc.) and LP tokens.

How much leverage is out there in DeFi?

Note: some of this is already automated in DeFi 2.0, e.g. Abracadabra's Magic Internet Money (MIM), where liquidations are more severe from repeated leverage. **[work in progress]**.

The basic tasks of lending

- Underwrite
- Monitor & service
- Collect

Can we build a financial system on one-shot games?

“Let’s throw away this technology – it’s a social technology rather than a mathematical technology – of **repeated game and reputation** and let’s try and build a system that is going to operate purely on the basis of an **algorithm** that assures us that we have what we need.”

Prof. Krugman was talking about cryptocurrencies then, but this issue of blockchain permissionless pseudonymity is **even more pertinent for DeFi.**

A Skeptic's View of Crypto (from the Point of View of Monetary Economics)

33,648 views • Nov 3, 2018



a16z
84.8K subscribers

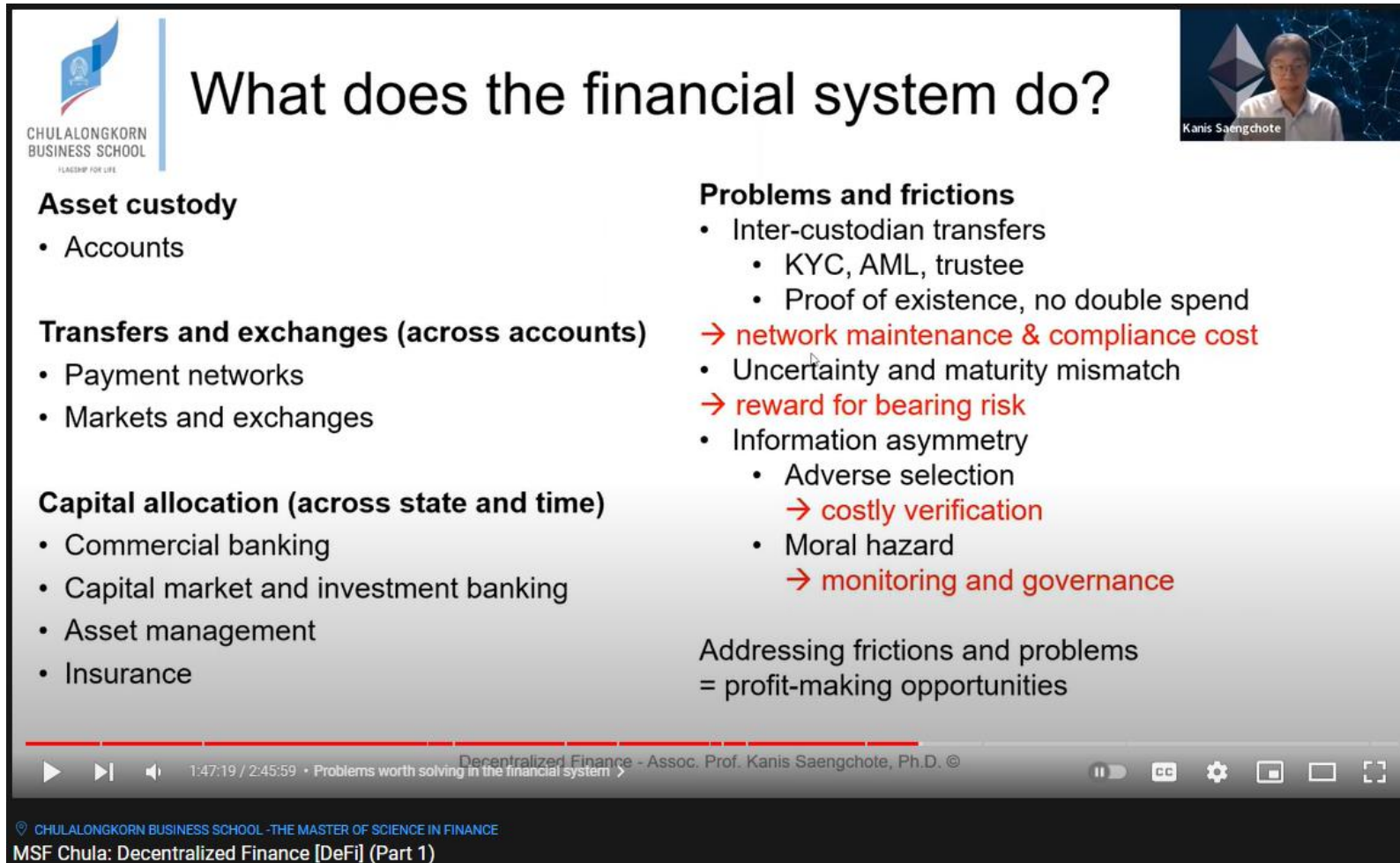
Key Takeaways

- **Lending protocols facilitate leveraged investment strategies.**
Our evidence: large wallets, yield aggregators and smart contracts are more likely to redeposit their borrowed tokens for liquidity mining/yield farming incentives and the presence of yield aggregators as biggest holders of cDAI and cUSDC in Feb 2022. [leveraged yield farming].
- **DeFi changes repeated games to one-shot games → collateral matters!**
 - Protocols underwrite collateral, not borrowers, so collateral choice and overcollateralization are important. Already hard for on-chain collateral; even more so for off-chain collateral.
 - Liquidations are necessary and do occur in Compound but are small because of ample overcollateralization. New gen protocols (repeated leverage) have much larger liquidations.
 - **Challenge and opportunity: what is a meaningful identification in DeFi? Decentralized ID?**
- **DeFi is permissionless, composable and transparent, but not easy to understand!**
Without proper accounting and surveillance, systemic risk can build up easily.

Additional Materials

Master's level lectures (~6 hours) on DeFi with updates until Jan 2022.

Available at: <https://youtu.be/-4lKmKjo9q4> or
<https://dr-kanis.com/2022/02/14/a-financial-economics-approach-to-defi/>



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What does the financial system do?

Asset custody

- Accounts

Transfers and exchanges (across accounts)

- Payment networks
- Markets and exchanges

Capital allocation (across state and time)

- Commercial banking
- Capital market and investment banking
- Asset management
- Insurance

Problems and frictions

- Inter-custodian transfers
 - KYC, AML, trustee
 - Proof of existence, no double spend
- network maintenance & compliance cost
- Uncertainty and maturity mismatch
- reward for bearing risk
- Information asymmetry
 - Adverse selection
 - costly verification
 - Moral hazard
 - monitoring and governance

Addressing frictions and problems
= profit-making opportunities

1:47:19 / 2:45:59 • Problems worth solving in the financial system

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MSF Chula: Decentralized Finance [DeFi] (Part 1)