Decentralized Finance

Synthetics, Derivatives and Tokenized Assets

Instructors: Dan Boneh, Arthur Gervais, Andrew Miller, Christine Parlour, Dawn Song





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Definitions/Questions

Derivatives are contracts/assets that payoff conditional on an event (usually price of another asset) some time in the future

Agree on contract

Event Occurs

Payment

Questions

1. Why are they designed the way they are?
2. What kind of event can we agree on?
3. How do we guarantee payment (“counterparty risk”)

Why are there derivatives?

Used since antiquity (described in Hammurabi's code)

The"state" was determined by harvest outcomes.

Farmers need resources to plant today, but their ability to repay is uncertain.

Useful in markets with obvious hedgers and speculators.

Modern Futures Contracts

Futures are standardized contracts that are designed to get the largest volume of trade.

Traded on various exchanges (NYMEX, CME, CBOT etc.)

All these exchanges are part of the CME group

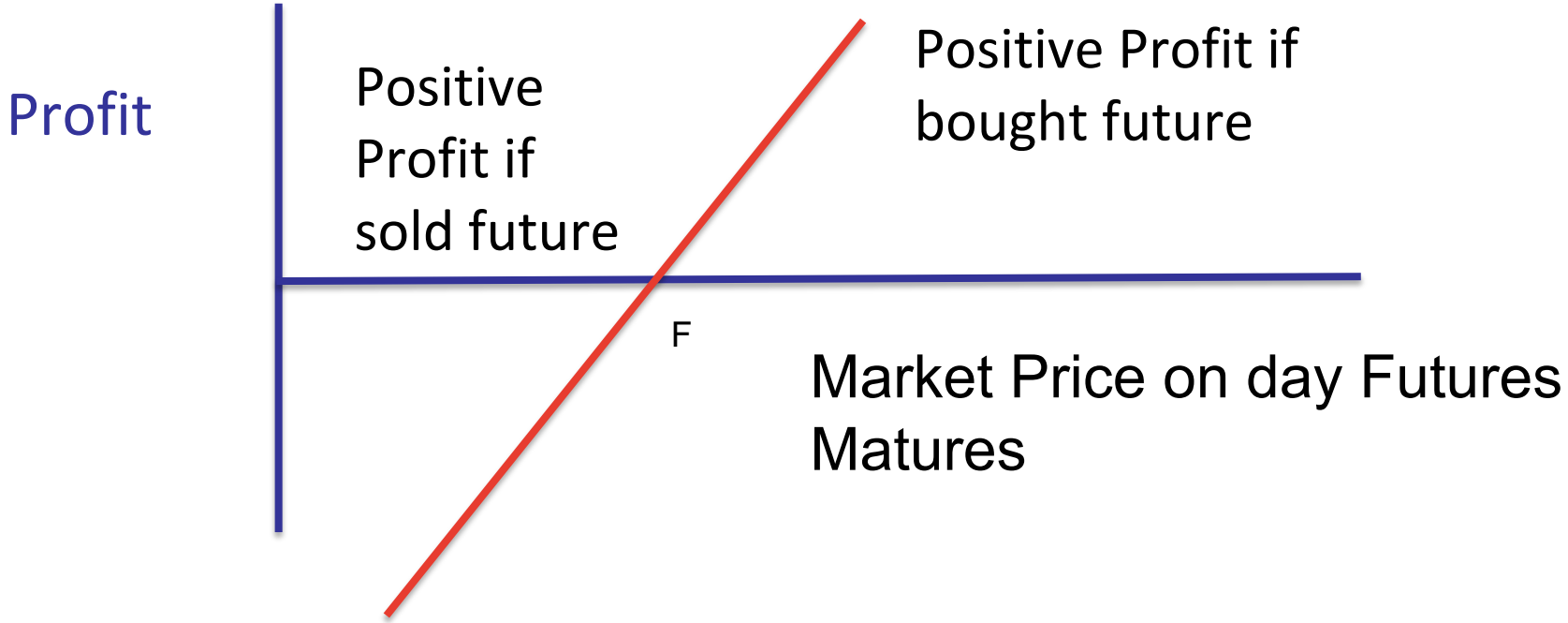
Futures and Forwards: Buy now, settle later

Agree to trade in the future at $F

Trade happens at $F

The market price can move up or down

Payoff to a Futures contract to buy at price F



Futures can be cash or physically settled

1. Physically settled: the actual underlying is exchanged (commodities such as oil, wheat)

   Useful for producers and processors

2. Cash settled: a cash payment based on the current market price

   Useful for investment strategies

Cash settled Futures contracts are offered in various sizes

The S&P futures contract is based on the S&P index.

The dollar value of the contract is $250 per point in the index

- If the index is 100, one futures contract is worth $25,000

The E-Mini futures contract is $50 per point in the index

Difficulties with a lag

Futures usually admit high leverage

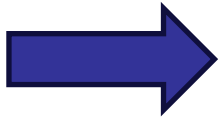
Magnifies gains and losses and magnifies risk the losing side will default.

Solution: Standardized futures:

1. Marking to Market
2. Central Clearing

Margin and Marking to Market

Initial Margin set by the exchange and depends on the asset volatility.

Variance or maintenance margin: if the dollar value in the account is too low  margin call.

Marking to market: each day the profits and losses from the new futures price reflected in the account.

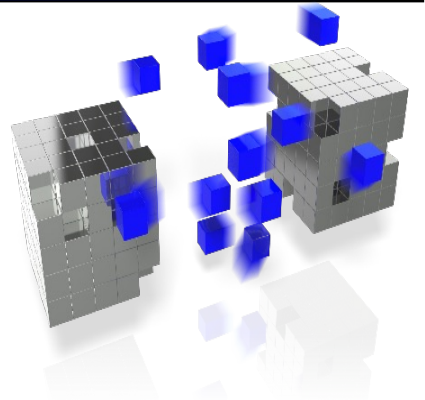
This ensures that there is a ``common'' futures price.

Long 1 contract for Silver on CME

DAY	Futures Price	Profit (Loss)	Margin
Today	5.10		
1	5.20	$0.10\times5{,}000 = 500$	500
2	5.25	$0.05\times5{,}000 = 250$	250
3	5.18	$-0.07\times5{,}000 = (350)$	-350
4	5.18	0	0
Settlement	5.21	$0.03\times5{,}000 = 150$	150

Central Clearing

- Nets trades
- Sequences of bilateral netting can be inefficient
- Assumes credit risk
- All Trades are against the ``house''
- Members pay margins



Perpetual Futures

Instead of fixed maturity futures, crypto innovation is a perpetual future i.e., one that never expires.

Designed to control credit risk and make the price track the underlying.

Product is popular (billions of dollars outstanding)

Perpetuals on dydx

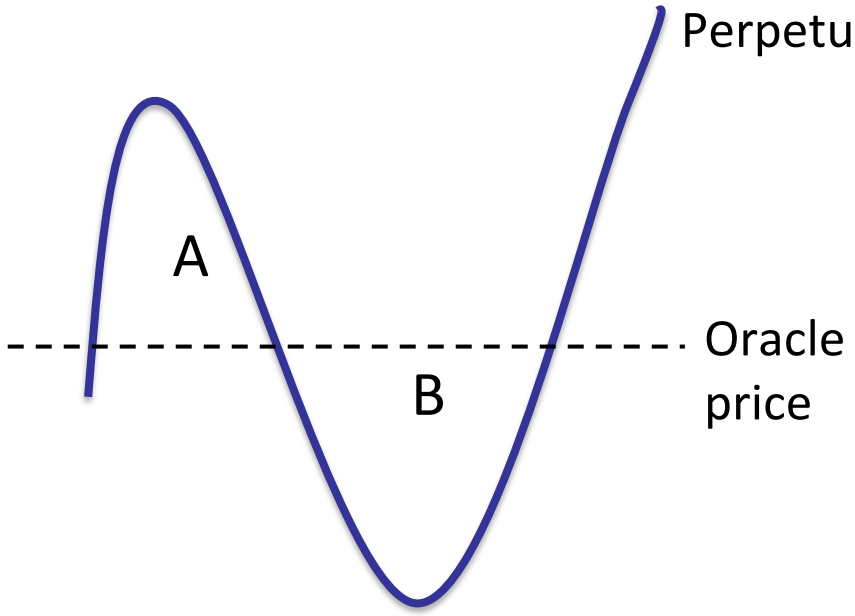
Collateral asset e.g., USDC

Special marking to market feature: funding payments

Order matching is done off-chain (scalability)

Non-custodial on-chain settlement.

How perpetuals track the underlying



- In region A, the perpetuals price is too high and the longs pay the shorts
- In region B, the perpetuals price is too low and the shorts pay the longs.

Leverage and Maintenance margins on Perpetuals

Different initial margins depending on the crypto

Maintenance margin triggers liquidation

High Leverage: BTC 20X, ETH 25X

Each perpetual has its own price increment, order size etc.

These features were chosen to maximize trade

Why are futures contracts designed like this?

1. Fills a missing economic function:
   - Risk sharing between producers and speculators.
   - Producers can lock in price today which makes planning easier.

2. Maximizes Market Liquidity:
   - Contract size (dollar value) chosen so most potential participants will find it attractive.
   - Exchange takes care of collateral management so traders don't have to expend time and effort to find a safe counterparty.
   - Common price due to marking to market makes it easier to trade.

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Derivatives to Borrow Cash or Securities

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Bilateral Derivatives: Swaps

Massive Market with industry body International Swap Dealers Association (ISDA)

Large institutions sign master ISDA agreements.

1. Currency
2. Fixed Income: Fixed rate for floating rate
3. Credit Default Swaps
4. Equity Return Swaps

Interest Rate Swaps

Both sides agree to a dollar size, a length of time and a periodicity.

One side owes a fixed percentage of the dollar size

The other side owes a floating percentage of the dollar size.

- Floating rate based on observed announced rates e.g. Secured Overnight Financing Rate (SOFR)

Cash flows are usually netted.

Fixed for Floating Swap

Owes floating % of swap amount

Owes fixed % of swap amount

Why are Swaps Designed this way?

Want a specific economic exposure but too expensive to sell + buy underlying.

Cash flows only exchanged on the notional value lower counterparty risk.

Flexible way to construct synthetic securities, i.e.,
credit default swap + treasury = corporate bond

Sidebar: Oracle Attack?

Valuation and trading of swaps is contingent on an easy to observe and trustworthy benchmark.

One of the floating rates used is the London Interbank Offer Rate (LIBOR)

Massive scandal in 2012 on the manipulation of the rate by traders.

- Revised formula, and current administered by ICE (owned by NYSE)

Collateralized Loans/Borrowing Securities

In TradFi it is done through Repurchase agreements

A repurchase agreement is an over-collateralized loan

The market is over 12 trillion USD

Participating institutions are money market funds, asset managers etc.

In DeFi, all loans are collateralized

Repurchase Agreements

Collateral + Promise to Repurchase

Cash

Triparty Repo

Instead of two counterparties exchanging cash or securities

Both parties conduct the agreement through a third party – a custodian.

This enables efficient use of collateral/netting

Everyone is exposed to the custodian bank which is a source of systemic risk.

Economic Use of Repos

Someone with excess cash (i.e., money market fund), can lend it out with a Repo.

Someone who needs a specific security for settlement or trading strategy (e.g., short selling) can enter into a repurchase agreement.

Repos are also used to lever up a position (i.e., borrow to invest).

Using Repurchase Agreement to borrow

A trader can use a sequence of Repos to magnify their risk and return.

Repos are overcollateralized, so $100 of collateral yields less than $100.

The difference is called a “haircut”

A trader can enter into a sequence of repos, using the borrowed money to buy new securities etc.

Leverage using Repos

Security worth $100

Use as collateral to borrow $100-h

Buy a security worth $100-h

- Portfolio depends on $200-h of the security
- Owe $100-h
- If haircuts are zero, infinite leverage is possible!

Similarity with DeFi Lending

DeFi borrowing and lending are over-collateralized

Structure is similar to Repos

Differences

1. Lenders can withdraw funds at any time
2. Lenders are paid a floating rate.
3. Borrowers' collateral is monitored at high frequency

Automated Collateralized Lending

Lenders

- Deposit crypto into a pool
- Interest paid is a function of ratio of borrowers to lenders
- Withdraw at any time

Compound

- Floating rate transfers run risk to borrowers.
- Liquidations done by profit maximizing 3rd party traders.

Borrowers

- Deposit crypto collateral into a smart contract
- Pay high frequency floating rate
- Liquidated if LTV is too high

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Synthetic Assets

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Designing/Manufacturing Synthetic Assets

1. Identify the economic/financial risk to be exposed to.
2. Robust way to measure/agree on changes in risk (oracle)
3. If no one owns the underlying, how to ensure payouts
4. How to make the new assets easy to trade (market liquidity)

Exchange Traded Funds

An exchange traded fund (ETF) is a type of security that tracks an index, sector, commodity, or other asset, but which can be purchased or sold on a stock exchange the same way a regular stock can.

E.g., SPDR S&P 500 ETF (SPY), which tracks the S&P 500 Index

Advantages

Diversification

Cheaper way to invest in specific/ targeted sectors

Only taxed when selling ETF; no tax while holding it

ETF basics

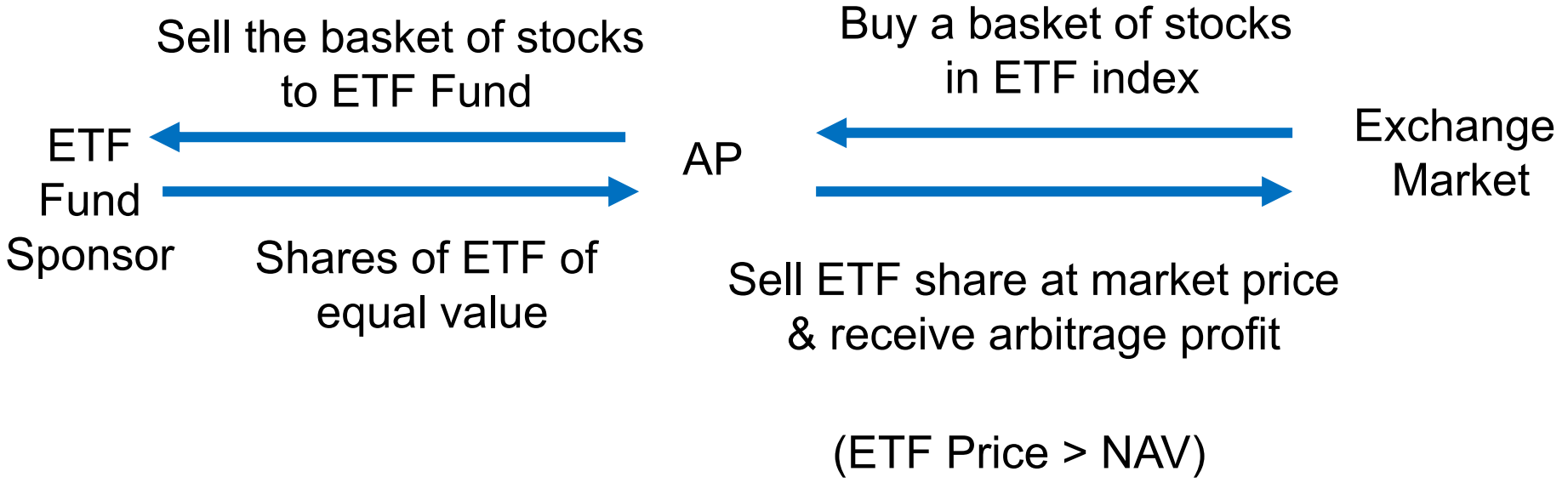
- Price per share determined via trading
- NAV (Net Asset Value): an accounting mechanism that determines the overall value of the assets or stocks in an ETF
- Premium/discount: difference between ETF price and NAV

ETF Operations

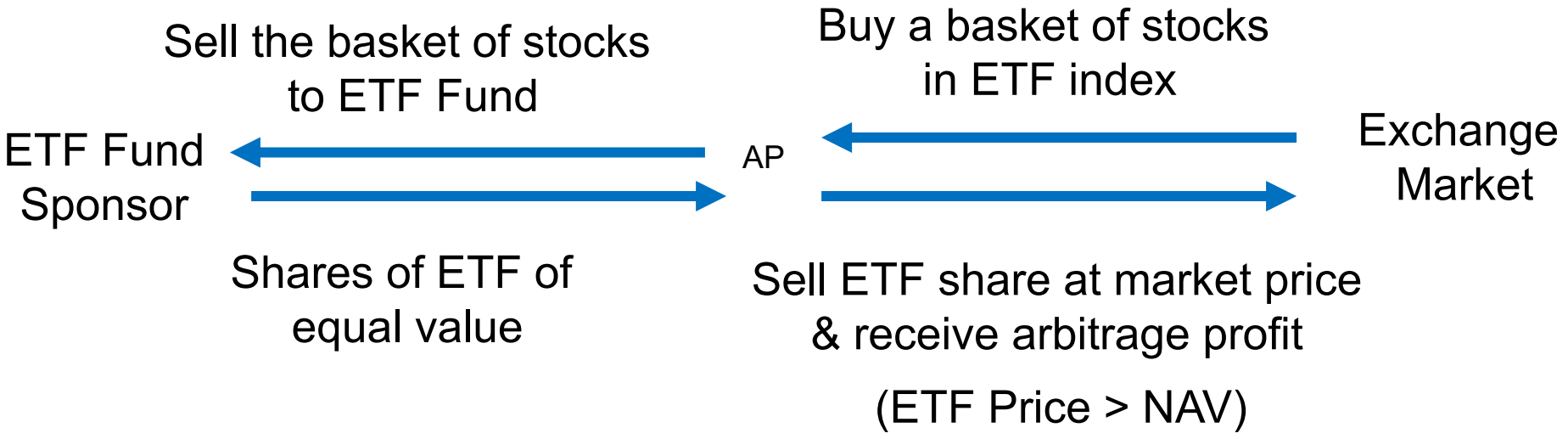
The supply of ETF shares is regulated by “creation and redemption” done by large specialized investors called authorized participants (APs)

Traditionally, authorized participants are large banks, such as Bank of America (BAC), JPMorgan Chase (JPM), Goldman Sachs (GS), and Morgan Stanley (MS).

ETF Share Creation/Issuance



ETF Redemption



Concerns with ETFs

Inefficiency

Intermediary: AP, taking arbitrage profit

Closed system, no open access

Only certain regulated entities can create new ETF funds

Trust third-party for custodial of assets

Crypto ETFs

Earliest Bitcoin ETFs invested in futures

BTC was determined as a commodity for regulatory purposes, and there is deep futures trading on commodities

More recently, regulatory approval to issued “spot” ETFs, that are backed by Bitcoin held in custody, similar to stock ETFs

Two ways to buy the underlying

Strategy #1

Buy it today and wait until the maturity date.

Cost today = Current Price

Strategy #2

Buy a futures contract and wait until maturity date to pay.

Cost today is the Present value of the Futures price

$$\frac{Futures\ Price}{(1+r)}$$

Spot Futures Parity

Both strategies allow you to have the good on the futures maturity date

By absence of arbitrage they must cost the same.

Current Price = Present Value of the Futures Price

$$P = \frac{Futures\ Price}{(1+r)}$$

Using Futures

Two strategies to invest in an asset for a month:

1. Buy the asset today and hold it
2. Enter into a futures contract and invest the present value of the futures price into a risk free bond.

Futures market can be used instead of buying the underlying directly.

Size of futures contracts

S&P E-Mini is $50 times S&P 500 Index

Micro E-Mini is $5 times S&P 500 Index

NYMEX crude oil based on 1,000 barrels

CME Bitcoin futures based on 5 Bitcoin

Micro Bitcoin based on 1/10 of a Bitcoin

CME Ethereum Contract based on 50 ETH

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Tokenization

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Transaction Frictions

Transfer $$ through payment system

Transfer security title through settlement system

Economic Costs in Current System

- Clearing requires coordinated data
- Settlement uncertainty
  - Collateral has to be posted
    - Opportunity cost of capital
  - Securities have to be moved between sub-custodians
    - Fails
  - Limited Time windows
    - Jump Risk when markets are closed

Economic Models of Tokenization

1. Native tokens
   - Assets issued on-chain
   - Flexibility to design new types of assets (token is code)
   - Legal and regulatory issues

2. Non-native tokens
   - Financial institution holds RWA in custody
   - Issues tokens against them
   - Requires trust in the institution

Case #1: Native Tokens

HSBC Orion

- Regulated under Luxembourg digital asset/blockchain legislation

Central Account Keeper (CAK) like a Custodian

Issues wallets and initiates transfers

- Hyperledger but mirrored on Ethereum

Settlement token (specific payments not generalized)

Floating rate bond with the European Investment Bank (EIB)

Goldman Sachs Digital Asset Platform

EIB issued 100 million Euro 2 year digital bond on Goldman Sachs GS DAP Jan 2023

HK monetary authority issued 100 million green bond using GS protocol.

Delivery against Payment using a Hashed Time Lock

Integrated into the Canton network which synchronizes across siloed blockchains

Economic Implications

Can reduce direct costs of issuing, custody and servicing.

If the blockchain permits different protocols (trade, lending) increase secondary market liquidity and use value of the asset.

Interoperability is very important, else blockchain operator has market power.

Form of interoperability is important else credit risk.

In DeFi Bridges are often hacked

Case #2: Real World Assets on Chain

Assets are issued in the usual way.

A custodian or another intermediary issues a token that represents the asset held in custody.

Token holder can redeem the RWA by redepositing the token.

Example: Stablecoins

Economic Benefits

Tokenization to increase secondary market liquidity

Tokenization to allow fractionalization.

Tokenization makes it easier to switch and use collateral

Align Technological transfer with title transfer (no fails)

Intraday Repo

Broadridge has converted custody relationships to tokenize collateral

Tokens repo’d on a permissioned blockchain.

Intraday repos are possible

Popular: 50bn daily

Coinvertible

Issued by Forge

A Euro demonimated digital asset under French Law

Economically like a Money Market Fund

Issued on the Ethereum blockchain – only available to whitelisted addresses

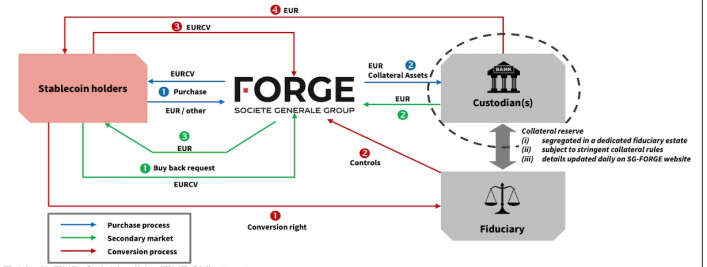

Table 2: EUR CoinVertible (EURCV) structure

BUIDL

Issued by Blackrock through securitize.io

Tokens on the Ethereum Blockchain

Underlying assets: cash and short treasuries

Held in custody by Bank of New York Mellon

Minimum investment is $5 million

Ondo Finance

Tokens are claims to i-shares short term treasury and some cash holdings.

Convenient and easy to use for payments

Also bears interest

Model is potential competition to interest bearing deposit accounts.

Liability Network

Regulated financial industries are designing other products that can be used for payments.

Citi has proposed a “Regulated Liability Network’’

- National currencies or “regulated liabilities”
- Interoperable
- Prevents dollarization

Things to think about

Current clearing and settlement is slow. Is this a good thing?

Are tokenized assets more “fragile”?

Are automated systems more or less secure?

What changes should be made in securities law/regulation?

Are there new sources of systemic risk?