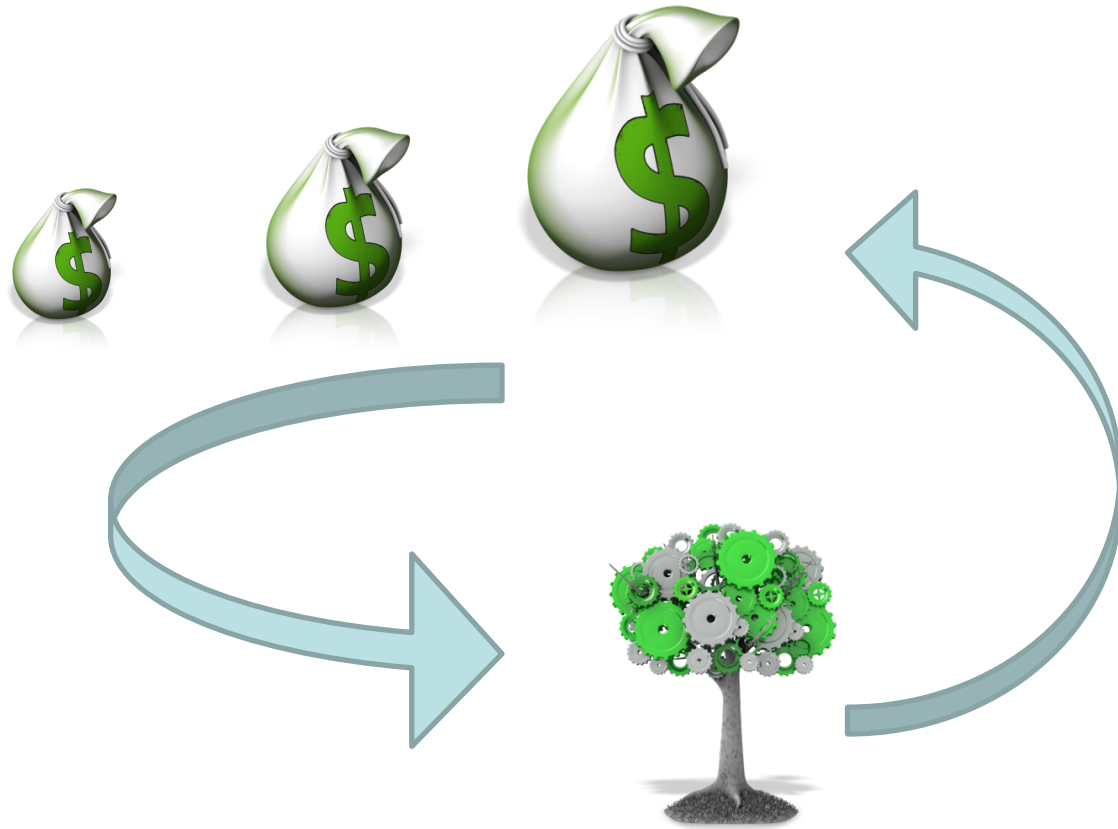# Decentralized Finance

Traditional Finance

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

The Finance Problem

1. Personal Investment: Build wealth across time and for different possible circumstances (states)

2. Business Investment: Provide entrepreneurs and firms with resources to invest in productive activities.

Goal: Allocate all resources efficiently across **time** and **states of the world**
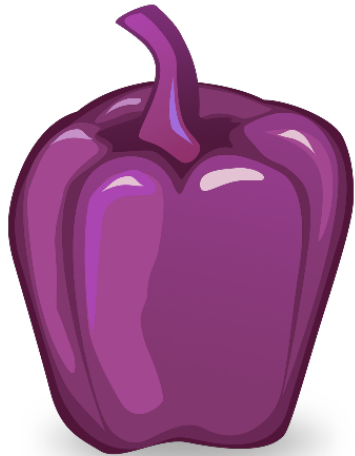
What is a state in finance?

- A state is a description of something that could happen.
  - Usually relevant to someone's utility/payoffs
- States may be observable and/or verifiable and contractible.

- Distinguish between two types of states:
  1. States that affect everyone.
  2. States that only affect one or a few people.

Utility in Finance

- Agents can rank outcomes (ordinal measure) ``Utility''
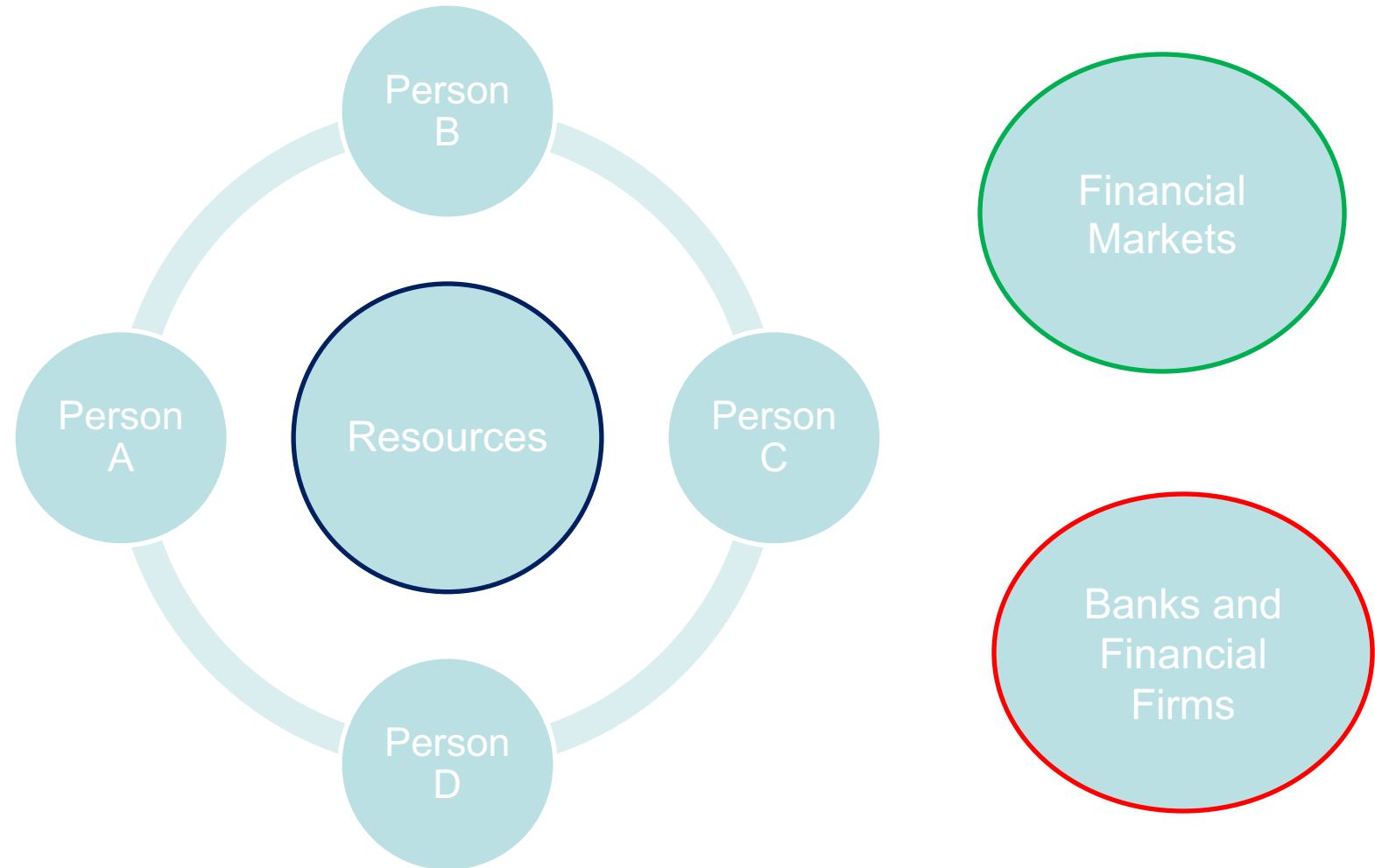- Assign probabilities to states and take expectations

- Hot chocolate dessert gives me 20 utils

- Purple pepper dessert gives me 10 utils

- Agents don't like risk and will pay to avoid it.

How does the Current System Solve the Problem?

- Financial Assets (stocks, bonds, insurance) are contracts that govern when and how real resources are divided up across states of the world.

- The legal system allows these contracts to be enforced.

- Regulators oversee the system

Regulators

- **Naïve Investors should not be harmed if they participate.**
  - E.g., Securities and Exchange Commission (SEC)
    - Disclosure Rules
    - Fiduciary responsibility
- **System should not be used by bad actors**
  - Know Your Client (KYC), Anti Money Laundering (AML)
- **The system should not create its own risks**
  - Bank Capital Regulation, Insurance Capital Regulation

Spillovers/Externalities/Market Failures

- **Externality: Agents' actions benefit or harm others.**
  - Stock prices help a third party with their decisions.
  - The direct market participants don't take this into account.

Systemic Risk:
Distress in one firm spills over to another

Bank run:
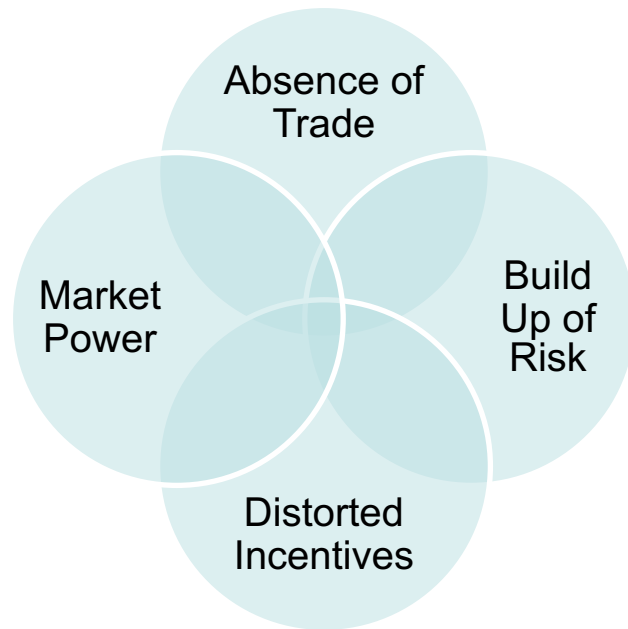depositors withdraw cash they don't want because they worry about bank collapse.

Market Breakdown:
Something prevents beneficial trade.

Evaluating a Financial System

- Straightforward to compare two systems we can observe.
- Costs and benefits that we do not observe that still should be evaluated:

- Trades that don't happen
  - If trades increase utility, not trading is a lost opportunity.
- Build-up of Systemic Risk
  - System failure is rarely observed but the risk of an event increases over time.
- Inefficient split of trade benefits.
  - Monopolists distort prices

A financial system works well if:

- Goods are allocated to the people who value them the most.
- People willingly participate in the system.

- Regulators make sure ``spillovers'' are managed in everyone's best interests.

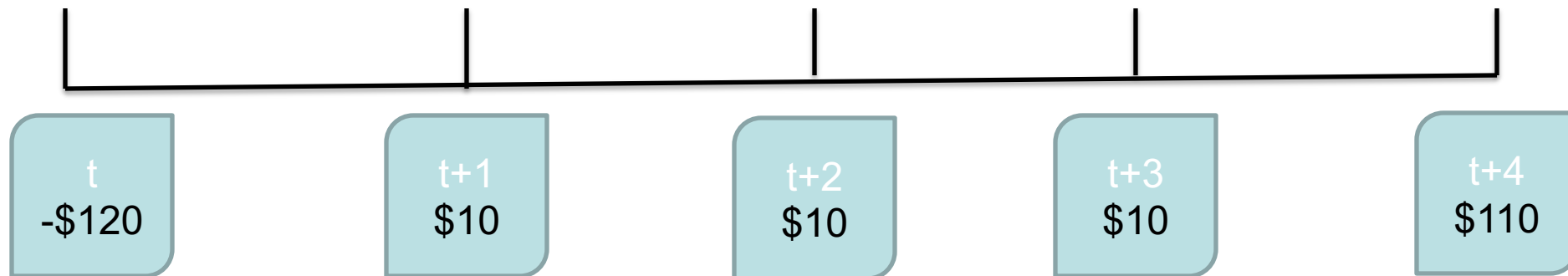- Mechanism Design makes these statements precise.

Financial Instruments

Standard Financial Instruments

- There are a few common financial instruments
  - Bonds or fixed income
  - Equity or stocks
  - Derivatives: e.g., Options
  - Time delayed: e.g., Forwards and Futures
- All have payoffs defined over **time** and over **states**

Bond: An investment that pays off over time

- A bond or a fixed income security typically pays off a fixed amount every period until the principal is repaid.
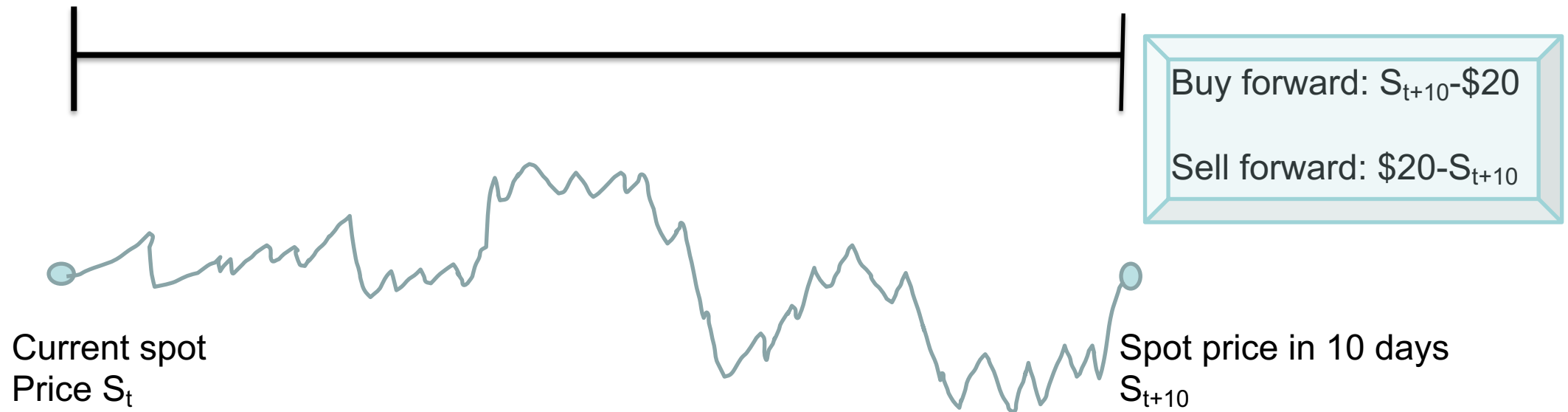- Cash flows of a 10% coupon bond with a market price of $120

t	t+1	t+2	t+3	t+4
-$120	$10	$10	$10	$110

Principal of $100 + last coupon payment

Buy Now, Pay later: Futures and Forwards

Agree today to
trade in the future
at price $20

Trade: 10 days later
Settle in Cash or
Underlying

Buy forward: $S_{t+10}-\$20$

Sell forward: $\$20-S_{t+10}$

Current spot
Price S_t
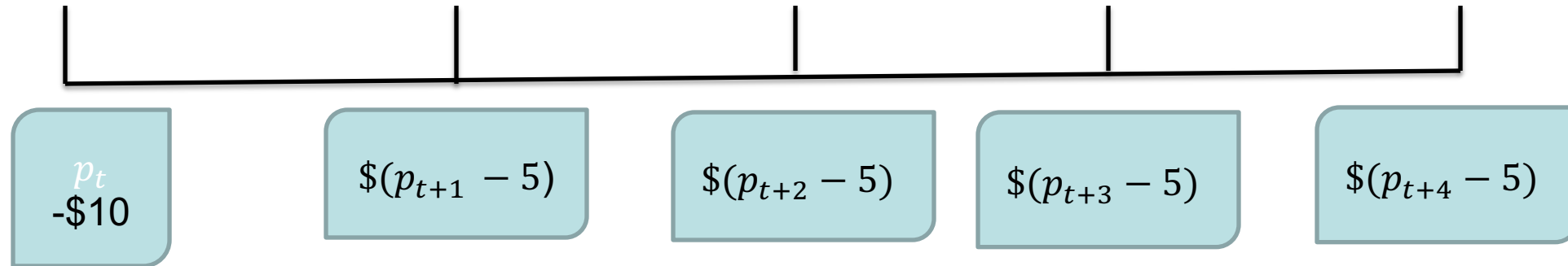
Spot price in 10 days
S_{t+10}

Stock: An investment that pays off over time AND states

- Perpetual claim that pays off forever.
- The payoff is called ``a dividend''
- The payment is discretionary and depends on if the company is doing well
- State depends on the company's fortunes
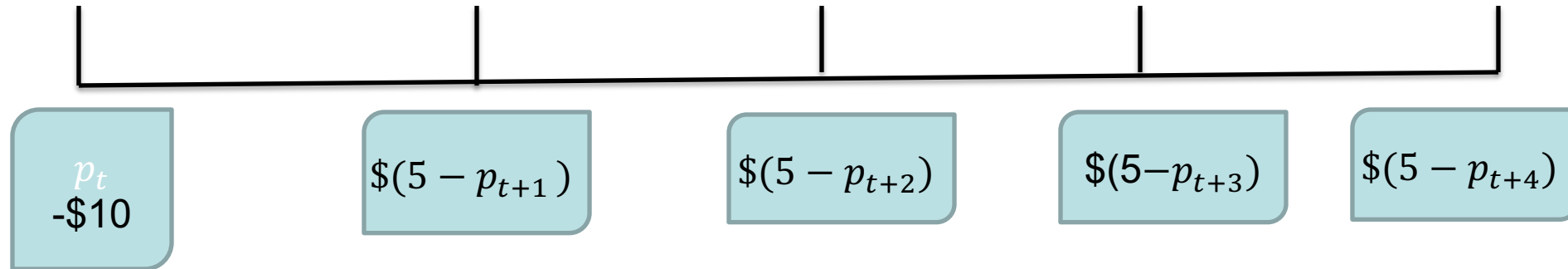- Cash flows of a stock that costs $100 and pays off dividends that are growing at 5%

t	t+1	t+2	t+3
-$100	$1	$1.05	$?

Payoff **derived** from stock price

- Call Option: Pay $10 for the right to buy a stock at a price of $5

  - Payoff at any point is (current price – $5)
  - Because this can be negative, you don't have to take it (you have the option)
  - State is defined by the underlying stock price.

Payoff **derived** from stock price

p_t
-$10

$(5 - p_{t+1})$

$(5 - p_{t+2})$

$(5 - p_{t+3})$

$(5 - p_{t+4})$

- Put option: Pay $10 for the right to sell a stock at a price of $5.

- Payoff at any point is ($5 – current price)
- Because this can be negative, you don't have to take it (you have the option)
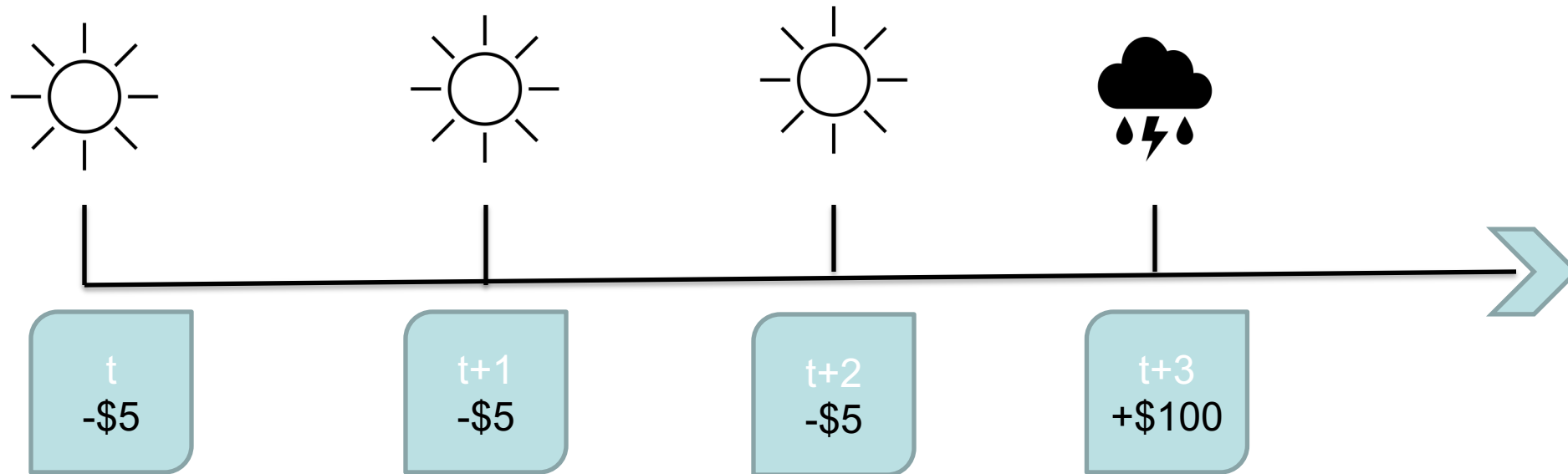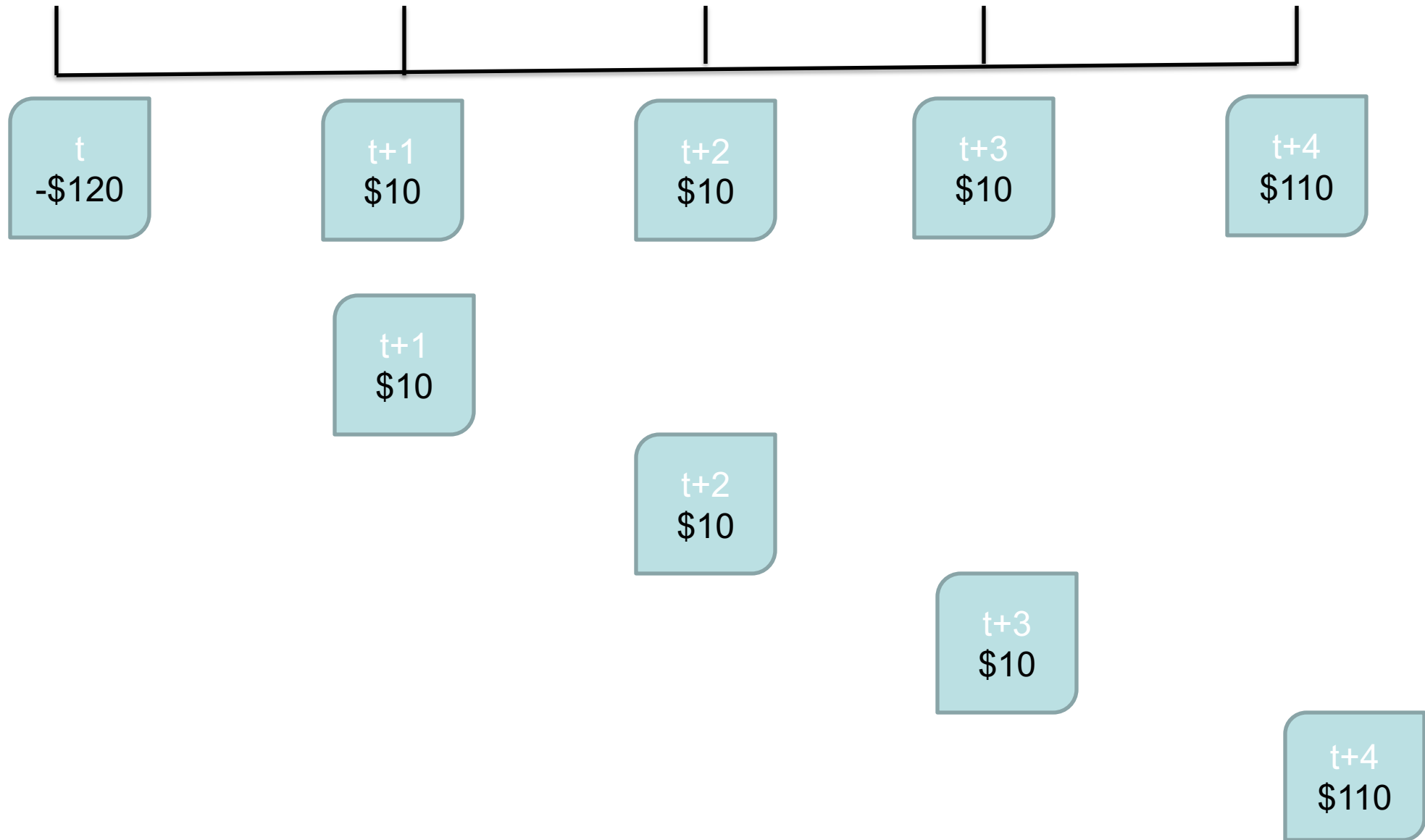- State is defined by the underlying stock price.

Insurance pays off on specific risk

- Insurance contract with a premium of $5, that pays off if your house is damaged.
- State is specific to you

Revisiting the 10% Coupon bond with a price of $120

Properties of Financial Assets

- Financial Assets are composable ``Value Additivity''
- How you divide/add up assets does not affect their value.

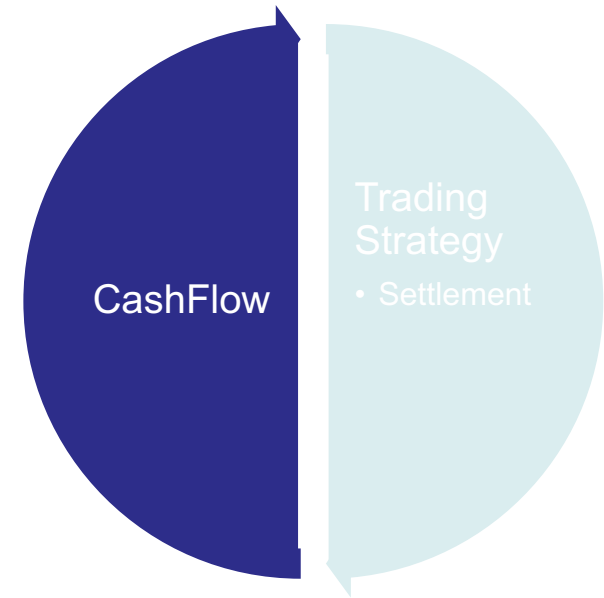- Some assets also embed other parts of the financial system.

Components of a bond

- **A bond is a bundle of cash flows and precommitment to trade.**

- Historically, periodic payments made lenders more comfortable.
- No economic reason to retain this design.

Who Trades

Investors

- **Retail Investors/households**
  - Risk Averse: prefer a sure consumption stream over an uncertain one that has the same expected value

    - Increase Wealth
    - Hedge Risk

- **Hedge Funds and Institutions**
  - Sophisticated and informed

    - Make Profits
    - Private information

Retail Investors

- Don't trade on superior information.

- Frequently hold **inefficient portfolios**
  - Not properly diversified (too much risk for the return)
  - Buy the wrong sorts of assets

- Face high trading fees (implicit and explicit)
- Trade too much

Hedge Fund Portfolios

- Hedge Funds take investor capital and produce different risk and return profiles.

Hedge Funds and Proprietary Trading

- Take (frequently) levered bets on (legal) private information.
  - Leverage is borrowing to invest.
  - Leverage increases the risk and return

- Example: Invest $1 of your own money and borrow $0.50 to invest $ 1.5 in the stock. (Suppose that the borrowing rate is zero and suppose that the stock price which is currently $1, either halves or doubles with equal probability.)

Outcome	Stock	Loan	Total	Portfolio Return
100%	$3	($0.50)	$2.50	150%
-50%	$0.75	($0.50)	$0.25	-75%

Leverage

- Simplest way to obtain leverage is to borrow money to invest.
- Sophisticated investors use derivative securities
  - The value of derivative securities is in reference to an underlying asset.
  - E.g., Options, futures, contracts for difference
- Typically derivative trading requires an initial margin
  - Safe assets posted as collateral

Example: Archegos

- Borrowed from multiple prime brokers
- No information sharing

Value of collateral fell	Could not replace margin	Assets sold	Prices depressed

- Very concentrated portfolio

Archegos

CREDIT SUISSE

NOMURA

Goldman Sachs

Events that affect multiple financial institutions at the same time are Systemic

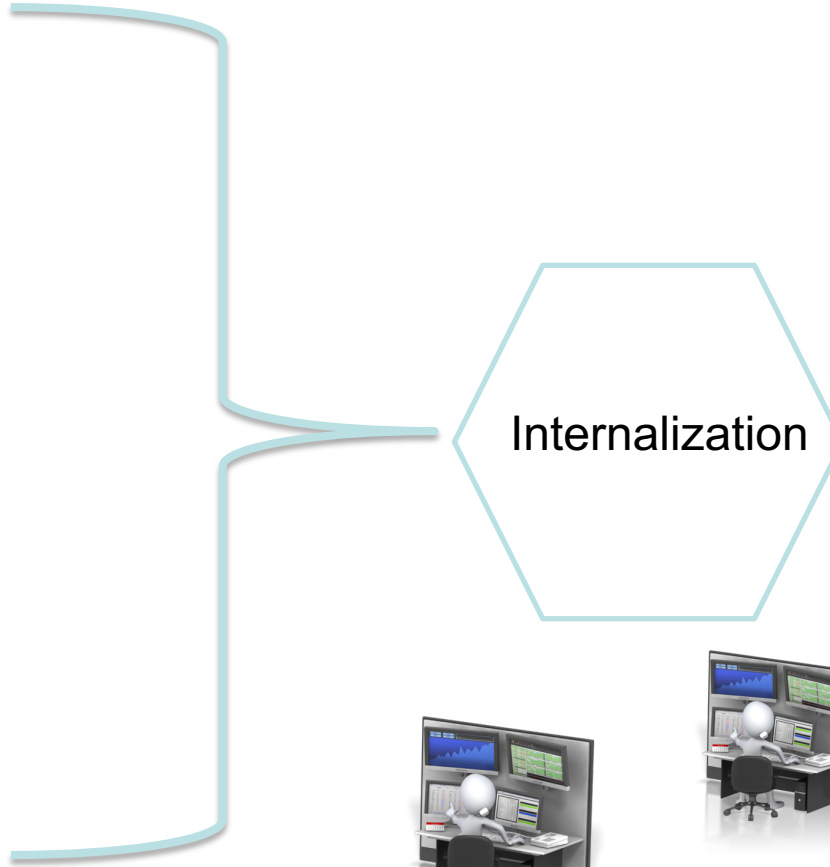Systemic events concern regulators system collapse.

How People Trade

Broker

Mutual Fund

Exchange Traded Fund

Internalization

National Market System
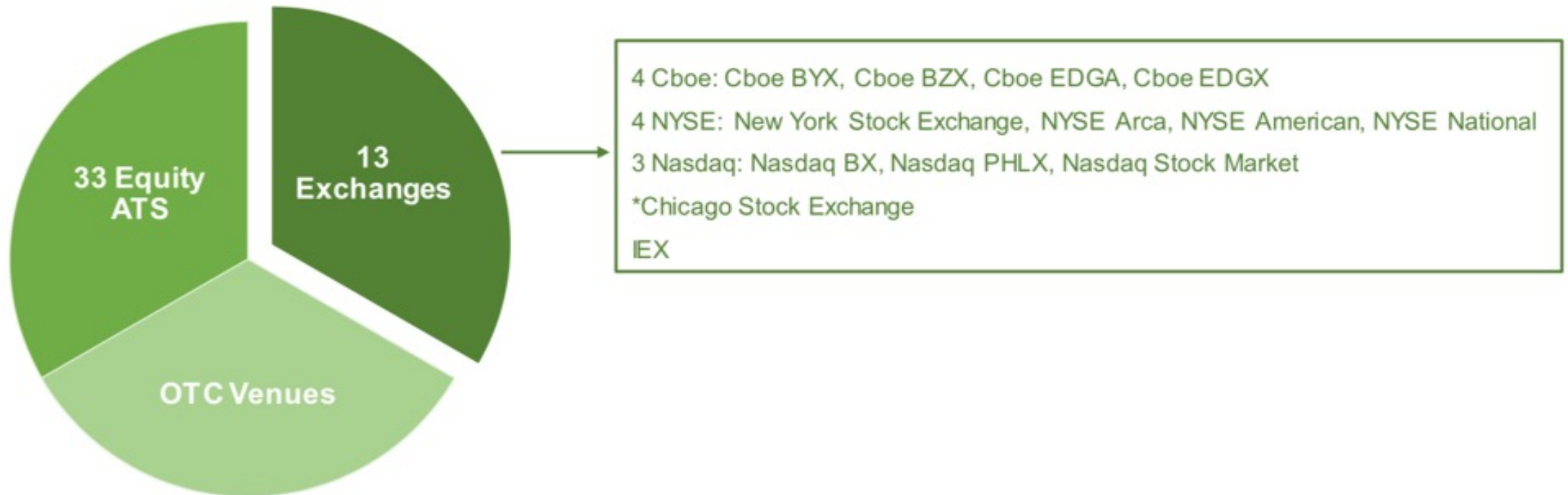
Multiple Exchanges linked by regulation

DTCC Custody Central Clearing

Ownership is recorded

Competing Trading Venues

Source: Cboe Global Markets, FINRA, SIFMA estimates

Note: Intercontinental Exchange (ICE) owns the NYSE exchanges, as well as other exchanges and clearing houses across the globe. In April 2018, ICE announced it entered into an agreement to acquire the Chicago Stock Exchange (CHX), pending regulatory approval.

Competition Across Markets

Limit Order Markets

	10.4	**900**
	10.3	1,000
	10.2	1,000
ASK	10.1	500
	10.0	
400	9.9	BID
1,000	9.8	
900	9.7	

Offers to sell

Bids to buy

- Limit Order submitters compete with other liquidity suppliers on the same side.
- Their order only executes if a large enough liquidity demander comes to the market.

Trading Costs

- In a perfect world, trade occurs at the fundamental value
- Don't observe the fundamental value

$$\frac{Ask + Bid}{2} = midpoint$$

- Cost to buy immediately $\quad$ $Ask - midpoint$
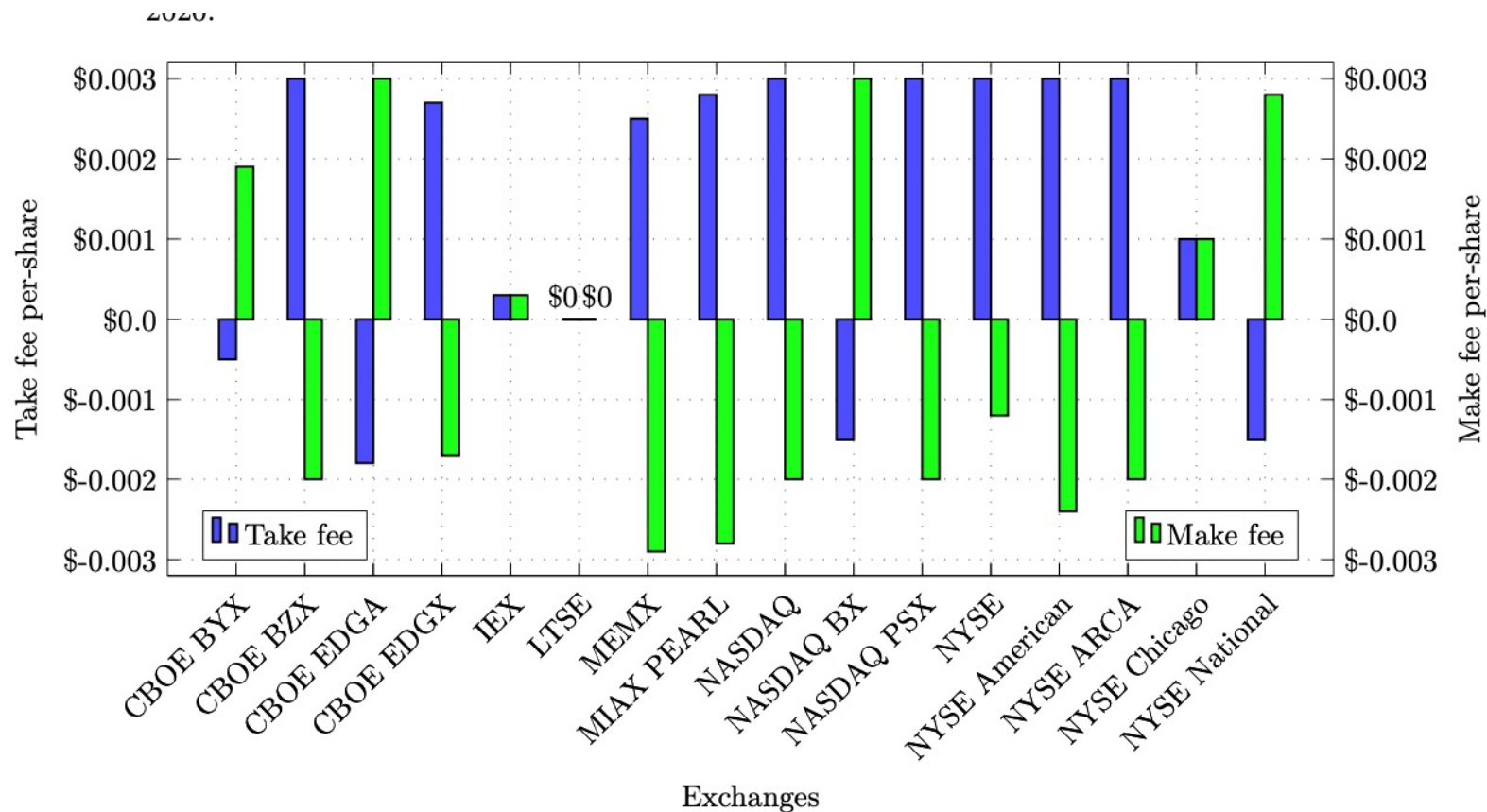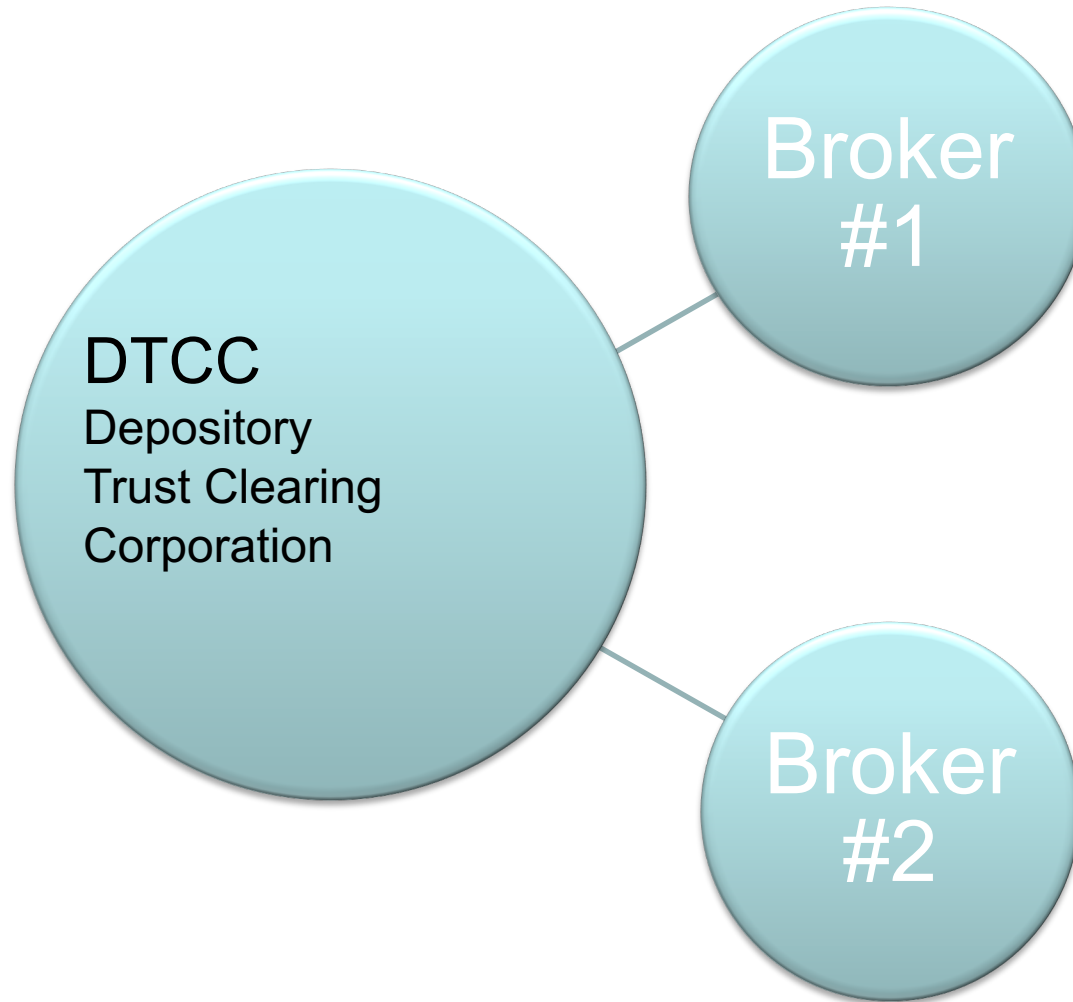- Measured $\quad$ $Spread = Ask - Bid$

Make Take Fees

Figure 2: Base make-take fees or net fees and take-fee ratios for NYSE-listed stocks charged by non-inverted exchanges in September 2020

CCP Mechanics

DTCC
Depository Trust Clearing Corporation

Broker #1

Broker #2

- Everyday, participants post margins based on trading volume
- Trades netted throughout the day, and margins may be increased.
- Margins provide insurance against any one party failing
- Central Clearing allows for netting of trades (vs gross flows)

Application: RobinHood/Gamestop

- RobinHood had to post margin at the DTCC
- Massive Volume of Trade in one direction
- Called on to post more margin.
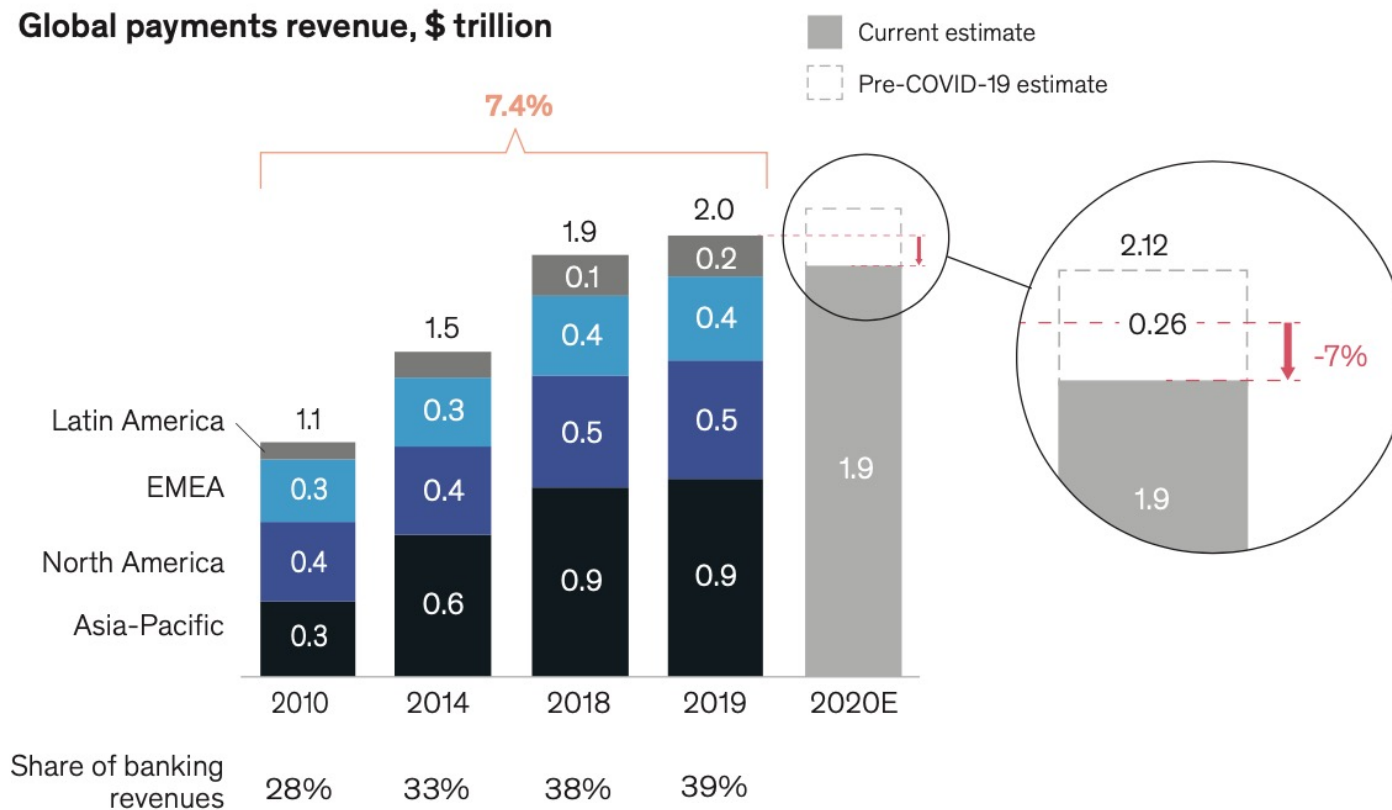- Could not borrow enough.

Payments and Money

Payments

- Processing payments is expensive.
  - Old estimate (2000) is 3% of GDP to process payments.
  - US lags behind many countries.
  - Consumers often don't see the costs.

- Current payment methods differ in speed, finality, liability.
- Multiple rails that allow value transfer

Payments are Lucrative

Global payments revenue, $ trillion

Current estimate
Pre-COVID-19 estimate

7.4%

Latin America
EMEA
North America
Asia-Pacific

	2010	2014	2018	2019	2020E
Total	1.1	1.5	1.9	2.0	
Latin America			0.1	0.2	
EMEA	0.3	0.3	0.4	0.4	
North America	0.4	0.4	0.5	0.5	
Asia-Pacific	0.3	0.6	0.9	0.9	1.9

2.12
0.26
-7%
1.9

| Share of banking revenues | 28% | 33% | 38% | 39% | |

Note: Figures may not sum to listed totals, because of rounding.
Source: McKinsey Global Payments Map

Money usually performs 3 functions

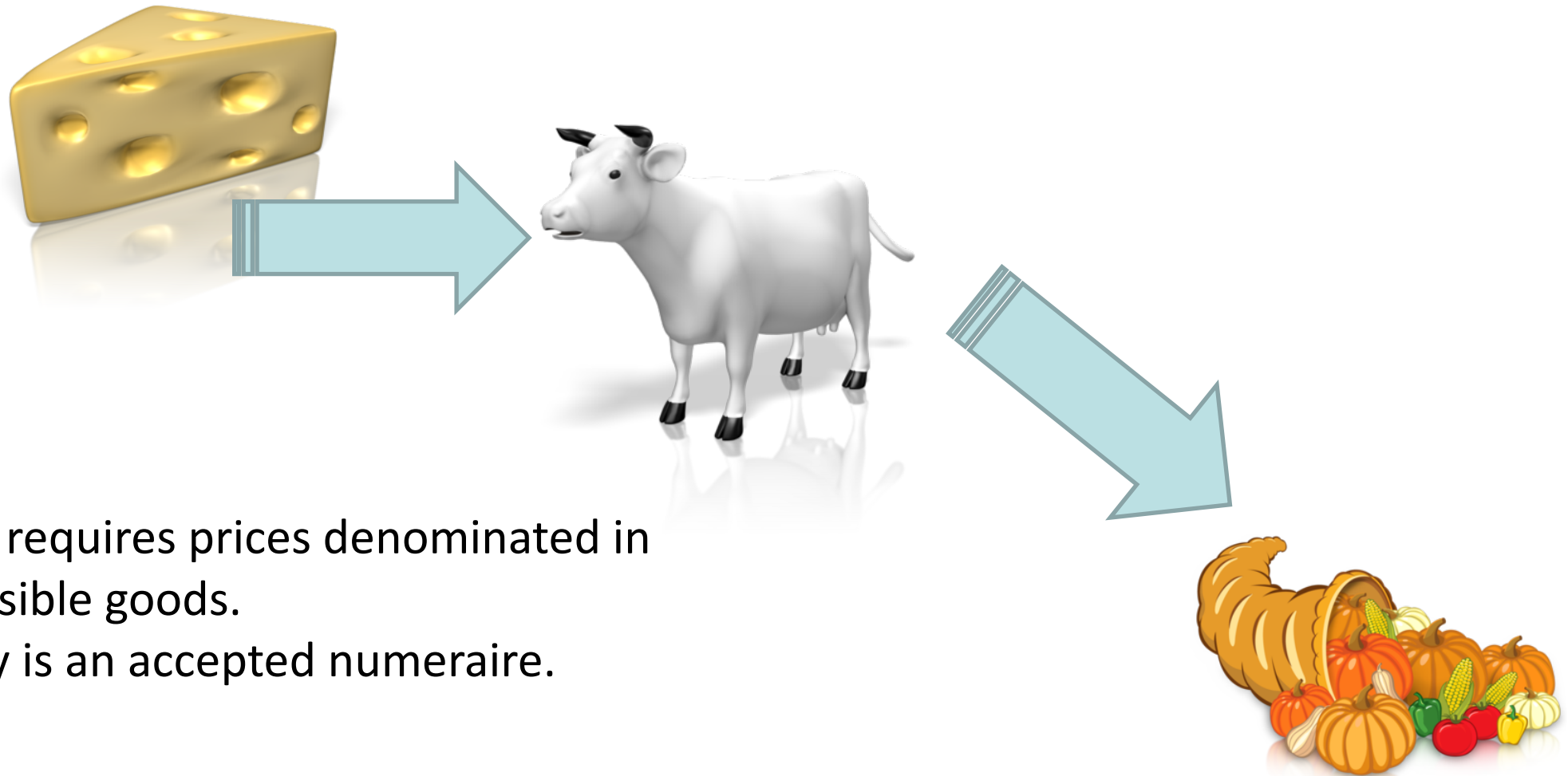1. (Stable) Store of Value.
   - ✓ Does not depreciate quickly

2. Unit of Account
   - ✓ Fees for all goods and services are stated in these terms.
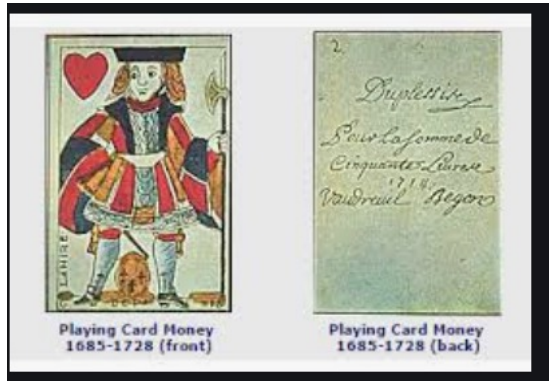
3. Medium of exchange
   - ✓ Easy/safe to use in transactions

Why the 3 Functions are important

- Barter requires prices denominated in all possible goods.
- Money is an accepted numeraire.

Money is a social institution that everyone accepts as an IOU

Playing Card Money
1685-1728 (front)

Playing Card Money
1685-1728 (back)

Mackerel Economics in Prison Leads to Appreciation for Oily Fillets

Packs of Fish Catch On as Currency, Former Inmates Say; Officials Carp

- Only hold money if at some point someone will accept it for a real good or service.
  - Gov't does this by accepting it as tax payments.
  - Gov't can also pass rules on 'legal tender'
- Only use fiat if the value will remain broadly stable over time (i.e., hold as a store of value until use as a medium of exchange).
  - Very important mandate of the central bank to ensure low and stable inflation. (Else, purchasing power falls and fiat is no longer a stable store of value.)

- In a modern economy, three types of money circulate and exchange at par.
    1. Physical currency, aka Fiat currency.
        - This is an IOU from Central Bank to Consumers.
    2. Central bank reserves.
        - These are an IOU from the Central Bank to Commercial Banks.
    3. Commercial bank money.
        - This is an IOU from Banks to Consumers.

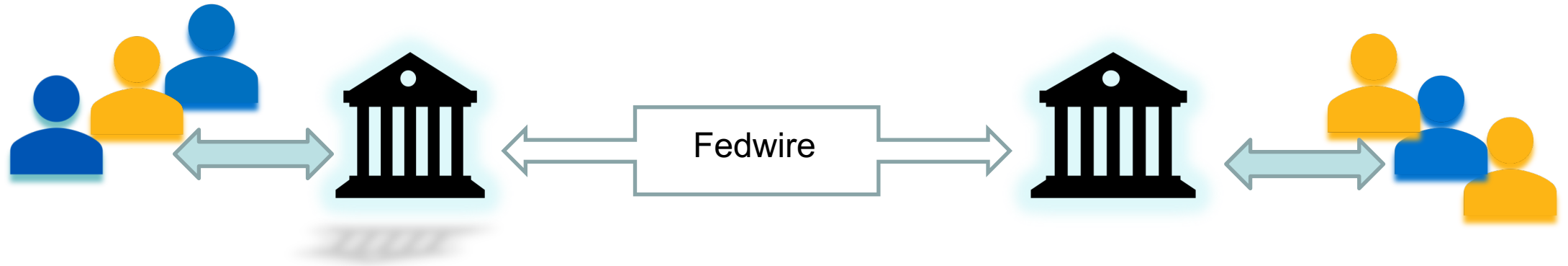- Money is a financial asset/liability

Standard Banking System and Making Money

- People put money in ``demand deposits'' for payments purposes.
- Banks make loans that are <u>partially backed</u> by deposits.
- Banks effectively create money
  - This is called ``inside money''
  - The system is called ``fractional reserve banking''

Most of the money in circulation is privately created by commercial banks.

Interbank Payments

- Consumer payments generate liabilities between banks.
- Interbank payments are settled through various wholesale platforms such as Fedwire, CHIPS
- Use of these platforms include a small nominal cost and implicit costs such as collateral requirements and daylight overdraft limits.

What does a bank do?

- Banks provide a bundle of services
- Organized this way for historical reasons
- No economic reason why these services should be bundled.

- Benefit of bundling to regulators: one entity is easier to regulate.