Commodity Market Derivatives

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Presentation Outline

1. Fundementals of Derivatives
2. Valuation and Portfolio Choice
3. Market Microstructure and Regulation
4. Conclusion

History of Futures Markets

- History of finance is about increasing complexity and increasing information
- History of futures markets is also a history of the modern world
  - Markets started as agricultural markets, added metals markets with the industrial revolution, and now are dominated by energy markets with the oil and electricity age

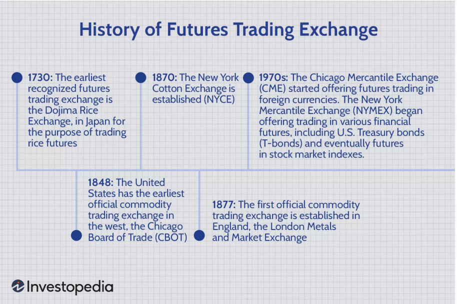

Figure 1: History of Futures Trading

Spot vs Futures Contracts

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- Spot prices indicate the cost of a commodity today for a specific location
- Spot markets tend to be dominated by physical participants and less liquid
- Futures prices indicate the price of the commodity at certain preset locations at specific dates in the future
- Futures contracts tend to be a mix of speculators and physical market participants, significantly more liquid
- If I sell a futures contract, I agree to provide a set amount of a commodity or pay the price of the commodity at a future date
- If I buy a futures contract, I agree to either pay the price of or take delivery of a commodity at a future date

Characteristics of Futures Contracts

- Contract has quantity and quality of commodity
- Contracts require initial margin requirement to ensure investor can fulfill obligations
- Marked to market daily
- Delivery required at end of contract period. In Chicago, 15th of month of futures expiration
- When markets are very tight, prices can become volatile around settlement as traders close out contracts
- Contract provides list of acceptable geographic settlement locations

Does this happen?

- I think most people think futures contracts all settle in kind

Figure 2: Will you recieve a shipment of potatoes?

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- Sometimes, settlement in kind trades at a discount...

The Moral Hazard of Financial Settlement

Figure 3: Hard to tell the difference between nickel and painted rocks...

Basis

- Basis represents the difference between cash and futures price of commodity
- In general, spot price lower than future and basis should converge to cost of transportation as contract approaches expiration
- Basis represents the health of the market, positive basis means markets are very tight
- Suppliers really care about local basis. Ask a farmer!
- Basis can diverge based on local market dynamics

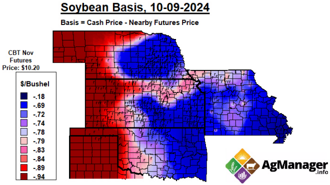

Figure 4: Midwest Soybean Basis

Backwardation vs Contango

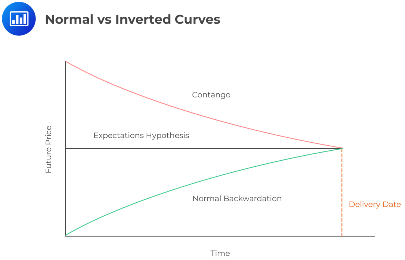

Figure 5: Futures price approaches spot price as delivery date approaches. When would this fail?

Backwardation

- In backwardation futures curve decreases by delivery date, spot price higher than futures price
- Normal because of time-value of money and market inelasticity
- Tight markets now, less tight markets in the future

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- In contango, futures curve increases by delivery date, spot price lower than futures price
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- Happens when markets are expected to become tighter in the future
- Often driven by the cost of storage
- In 2020, prices of oil went negative because there was nowhere to put it.
- Could you have traded on that?

How can Contango and Backwardization Exist at All

- Doesn't a predictable shift in market prices violate the efficient markets hypothesis?
- Why isn't someone arbitraging this?

How can Contango and Backwardization Exist at All

- Doesn't a predictable shift in market prices violate the efficient markets hypothesis?
- Why isn't someone arbitraging this?
- It is very possible that every price on the curve is correct
- Storage is not free, transportation is not free, investments have to be tied up to shift across time
- Cost of arbitrage may be less than expected benefit

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- Can the curve be in contango for some time periods and backwardation for others
- Of course, this is normal because of seasonal variation in commodities
- Even without seasonality, contango and backwardation coexist when markets are tighter in the medium run than in the long-run due to long-run market dynamics

Market Participants

- Hedgers
  - Physical market participants
  - Economic interest in commodity
- Speculators
  - Purchase derivatives with goal of predicting price movements
  - Only financial interest in commodity

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- Speculators can also cause bubbles and may create distorted signals in markets
- Speculators are not inherently bad, but uninformed or irrational speculators may negatively impact markets

What Moves Futures Markets?

Key Drivers:

- **Fundamental Factors:**
  - **Supply and Demand:**
    - Changes in production (e.g., weather, geopolitical disruptions).
    - Consumption trends (e.g., industrial use, seasonal patterns).
  - **Storage Costs:** Influence the shape of the futures curve (contango or backwardation).
  - **Economic Indicators:** GDP growth, inflation, and industrial activity.
- **Market Participants:**
  - **Hedgers:** Producers and consumers managing price risk.
  - **Speculators:** Traders seeking profit from price movements.
  - **Arbitrageurs:** Exploiting price differences between spot and futures markets.
- **Technical Factors:**
  - **Market Sentiment:** Reflected in trading volumes and open interest.
  - **Price Trends:** Moving averages, support and resistance levels.
- **External Influences:**
  - **Geopolitical Events:** Conflicts, sanctions, and trade policies.

Keynes-Hicks Theory of Hedging Pressure

- The Keynes-Hicks Theory of Hedging Pressure suggests that futures prices are affected by the risk preferences of hedgers.
- The theory posits that the risk premium in futures prices compensates for the pressure exerted by hedgers (typically producers) who seek to offload their risk.

Mathematical Formulation:

- Let F_t be the futures price at time t and S_T the spot price at maturity T.
- The expected spot price $\mathbb{E}(S_T)$ can be expressed as:

$$F_t = \mathbb{E}(S_T) - \text{Risk Premium}$$

- Risk premium, α, relates to hedging demand:

$$F_t = \mathbb{E}(S_T) - \alpha$$

where α reflects the demand by hedgers to insure against adverse price changes.

Example: Keynes-Hicks

Example:

- Suppose the expected spot price of wheat in three months is \$600 per bushel, but due to hedging pressure, futures prices are discounted by a risk premium of \$20.
- Then the futures price F_t can be calculated as:

$$F_t = \mathbb{E}(S_T) - 20 = 600 - 20 = 580$$

- This means the futures price today would be \$580 per bushel.

Working-Kaldor Theory of Storage

- The Working-Kaldor Theory of Storage links commodity prices and their futures to the costs and benefits of holding inventories.
- Storage costs and convenience yield (benefits of holding stock) drive the futures basis (the difference between futures and spot prices).

Mathematical Formulation:

- Let F_t be the futures price and S_t the spot price.
- The futures-spot price relationship can be expressed as:

$$F_t = S_t e^{(c-y)(T-t)}$$

  where c is the cost of carry and y is the convenience yield.
- Rearranging for the futures basis:

$$F_t - S_t = S_t \left(e^{(c-y)(T-t)} - 1 \right)$$

  which shows how storage costs and convenience yields impact the futures price.

Working Kaldor Graphically

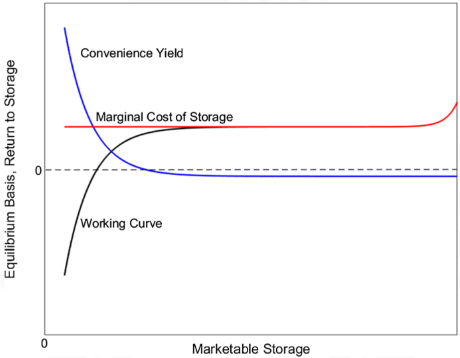

Figure 6: Nice Oil Prices you got there. Be a Shame if they... went Negative...

Working-Kaldor Example

Example:

- Suppose the spot price of oil is \$80 per barrel, the cost of carry is 5
- We can calculate the futures price F_t as:

$$F_t = 80 \times e^{(0.05-0.02)\times 0.5} = 80 \times e^{0.015} \approx 81.21$$

- Thus, the futures price for delivery in six months would be approximately \$81.21 per barrel.

Introduction to Options

- A financial option is a contract giving the buyer the right, but not the obligation, to buy or sell an asset.
- Two main types:
  - **Call Option**: Right to buy.
  - **Put Option**: Right to sell.
- Strike price (K): The agreed-upon price to exercise the option.
- Expiration date: The last date to exercise the option.

Put-Call Parity

- Fundamental relationship between European call and put options on the same underlying asset.
- Equation:

$$C - P = S - Ke^{-rT}$$

  where:
  - C: Call price
  - P: Put price
  - S: Spot price of the asset
  - K: Strike price
  - r: Risk-free rate
  - T: Time to expiration
- Ensures no arbitrage opportunities.

Put-Call Parity Visualized

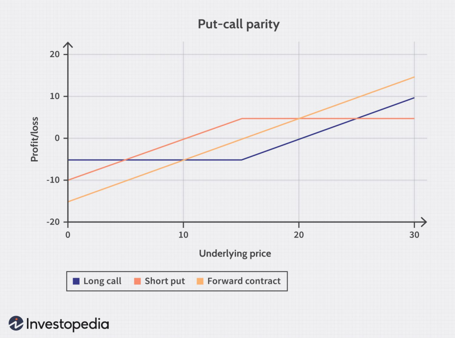

Figure 7: Arbagedden anyone?

Implied Volatility

- Implied volatility (σ_{IV}) is the market's forecast of the underlying asset's volatility.
- Derived from option prices using models like Black-Scholes.
- Reflects market sentiment:
  - High implied volatility: Greater uncertainty.
  - Low implied volatility: Lesser uncertainty.

Valuing Options: Binomial Pricing Framework

- The binomial model evaluates option prices by simulating possible paths the underlying asset's price can take.
- Assumes:
  - The asset price can either move up or down in discrete time steps.
  - Risk-neutral valuation to discount expected payoffs.
- Key parameters:
  - u: Up factor ($u > 1$)
  - d: Down factor ($d < 1$)
  - p: Risk-neutral probability
- Formula for p:

$$p = \frac{e^{r\Delta t} - d}{u - d}$$

- Option price:

$$C = e^{-r\Delta t}\left[pC_u + (1-p)C_d\right]$$

Binomial Asset Pricing Visual

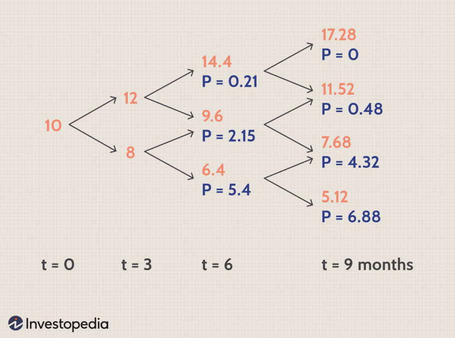

Figure 8: BAPM> CAPM?

Example: Binomial Option Pricing

Problem: Consider a call option with:

- Current stock price (S_0): \$50
- Strike price (K): \$52
- Risk-free rate (r): 5% per year
- Time to expiration (T): 1 year
- One time step (Δt): 1 year
- Up factor (u): 1.2, Down factor (d): 0.8

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Step 1: Calculate risk-neutral probability (p):

$$p = \frac{e^{0.05 \cdot 1} - 0.8}{1.2 - 0.8} = \frac{1.0513 - 0.8}{0.4} = 0.627$$

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Step 3: Calculate option payoffs at maturity:

$$C_u = \max(S_u - K, 0) = \max(60 - 52, 0) = 8$$

Example: Binomial Option Pricing

Step 4: Discount expected payoff to today:

$$C = e^{-0.05 \cdot 1} \left[pC_u + (1 - p)C_d \right]$$

$$C = e^{-0.05} [0.627 \cdot 8 + (1 - 0.627) \cdot 0] = 0.9512 \cdot 5.016 = 4.77$$

Option Price: $4.77

Introduction to Brownian Motion

- Brownian Motion, or Wiener Process, models the random movement of particles.
- It is a continuous-time stochastic process with key properties:
    - **Independent Increments**: Movements in non-overlapping intervals are independent.
    - **Stationary Increments**: The probability distribution of movement depends only on the length of the time interval.
    - **Normal Distribution**: Increments are normally distributed.
- Used to model asset price movements in financial markets.

Mathematical Definition of Brownian Motion

- Let $W(t)$ represent a Brownian Motion process where:

$$\begin{aligned} W(0) &= 0 \\ W(t) - W(s) &\sim N(0, t-s) \quad \text{for } 0 \leq s < t \\ W(t) &\text{ has continuous paths almost surely} \end{aligned}$$

- **Properties**:
  - $\mathbb{E}[W(t)] = 0$
  - $\text{Var}[W(t)] = t$
- Serves as the foundation for modeling random price movements.

Geometric Brownian Motion for Asset Prices

- Commodity prices are modeled using Geometric Brownian Motion (GBM):

$$dS_t = \mu S_t dt + \sigma S_t dW_t$$

- Where:
  - S_t: Commodity price at time t
  - μ: Expected return (drift coefficient)
  - σ: Volatility of returns (diffusion coefficient)
  - dW_t: Increment of Brownian Motion
- GBM ensures prices remain positive and models exponential growth.

Introduction to the Black-Scholes Model

- Developed by Fischer Black and Myron Scholes in 1973.
- Provides a closed-form solution for pricing European options.
- Assumes the underlying asset follows Geometric Brownian Motion.
- Key for understanding option pricing in commodities and financial markets.

Black-Scholes Formula for Call Options

- The price C of a European call option is:

$$C = S_0 N(d_1) - Ke^{-rT} N(d_2)$$

- Where:

$$d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r + \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

- $N(d)$ is the cumulative distribution function of the standard normal distribution.
- S_0: Current commodity price
  K: Strike price
  r: Risk-free interest rate
  σ: Volatility
  T: Time to expiration

Black-Scholes Formula for Put Options

- The price P of a European put option is:

$$P = Ke^{-rT}N(-d_2) - S_0N(-d_1)$$

- Parameters d_1 and d_2 are the same as in the call option formula.
- Reflects the right to sell the commodity at the strike price K.

Assumptions of the Black-Scholes Model

- Markets are frictionless (no transaction costs or taxes).
- Risk-free interest rate r is constant over the option's life.
- Volatility σ is constant and known.
- Commodity prices follow a continuous-time GBM with no jumps.
- No arbitrage opportunities exist.
- Options are European-style (exercisable only at expiration).

Application to Commodity Markets

- Commodities often exhibit mean reversion and seasonality, challenging the GBM assumption.
- Adjustments can be made to the model to account for:
  - Stochastic volatility
  - Mean-reverting price processes (e.g., Ornstein-Uhlenbeck process)
  - Convenience yield specific to commodities
- Despite limitations, Black-Scholes provides a baseline for option valuation.

Numerical Example

- Given:
  - $S_0 = \$50$ (current commodity price)
  - $K = \$55$ (strike price)
  - $r = 5\%$
  - $\sigma = 20\%$
  - $T = 1$ year
- Calculate d_1 and d_2:

$$d_1 = \frac{\ln(50/55) + (0.05 + 0.5 \times 0.2^2) \times 1}{0.2\sqrt{1}}$$
$$d_2 = d_1 - 0.2\sqrt{1}$$

- Use $N(d_1)$ and $N(d_2)$ from standard normal distribution tables.
- Compute C and P using the Black-Scholes formulas.

Limitations and Extensions

- **Limitations**:
  - Assumes constant volatility and interest rates.
  - Does not account for sudden price jumps or spikes.
  - Less accurate for long-dated options or illiquid markets.
- **Extensions**:
  - **Stochastic Volatility Models** (e.g., Heston model)
  - **Jump-Diffusion Models** (e.g., Merton's model)
  - **Finite Difference Methods** for numerical solutions

Kenneth Medlock's Model of Price Discovery in Commodity Markets

- **Overview:** Medlock's model focuses on how prices in commodity markets are determined through the interaction of supply, demand, and market structure.
- **Key Components:**
  - **Fundamental Drivers:**
    - **Supply:** Production costs, resource availability, and technology.
    - **Demand:** Economic growth, substitution, and end-use applications.
  - **Market Structure:**
    - Integration between physical and financial markets.
    - Role of storage and arbitrage opportunities.
  - **Expectations:**
    - Futures prices reflect market expectations of supply-demand balances.
    - Information asymmetry can impact short-term price discovery.
- **Key Insights:**
  - Prices serve as signals for resource allocation and investment.
  - Speculation and hedging play roles in price formation.

Example: Price Discovery in Natural Gas Markets

Scenario: Understanding price movements in the U.S. natural gas market.

- **Supply Factors:**
  - Increase in shale gas production due to advancements in hydraulic fracturing.
  - Seasonal production constraints (e.g., hurricanes disrupting Gulf Coast supply).
- **Demand Factors:**
  - Growing demand from LNG exports and power generation.
  - Weather-driven heating and cooling needs.
- **Market Structure:**
  - Financial trading on Henry Hub futures prices.
  - Arbitrage opportunities between physical delivery points.
- **Outcome:**
  - Futures prices signal expected supply-demand imbalances.
  - Short-term price spikes during cold weather (polar vortex) or shocks.

Applying Medlock's Model to a Commodity Supercycle

Application of Medlock's Model:

- **Demand Shocks:**
  - Rapid industrialization and urbanization (e.g., China's growth in the 2000s).
  - Long-term shifts in consumption patterns for commodities like metals, energy, and agricultural products.
- **Supply Constraints:**
  - Lag in supply response due to infrastructure, capital investment, and resource depletion.
  - Constraints in production capacity during peak demand.
- **Market Structure Dynamics:**
  - Integration of physical and financial markets amplifies price signals.
  - Speculative activity during perceived imbalances can exacerbate price volatility.
- **Role of Expectations:**
  - Futures prices anticipate sustained imbalances, incentivizing investment

The Commodity Supercycle

Figure 9: Commodity Supercycle

Commodity Portfolios and Their Valuation

- **Definition:** A commodity portfolio is a collection of investments in various commodity assets such as energy, metals, and agricultural products.
- **Key Components:**
  - **Physical Commodities:** Direct ownership of physical assets (e.g., crude oil, gold).
  - **Financial Instruments:** Futures, options, swaps, and ETFs tied to commodity prices.
  - **Diversification:** Exposure across multiple commodities to reduce risk.

Commodity Portfolios and Their Valuation

- **Valuation:**
  - **Spot Price:** Current market price of the commodity.
  - **Forward Curve:** The relationship between the spot price and future prices (contango or backwardation).
  - **Risk Adjustments:**
    - Commodity Beta: Sensitivity to market movements.
    - Volatility: Price fluctuations over time.
  - **Discounted Cash Flows:**

$$V = \sum_{t=1}^{T} \frac{E(CF_t)}{(1+r)^t}$$

    where $E(CF_t)$ are expected cash flows and r is the discount rate.
- **Portfolio Optimization:**
  - Use of metrics like Sharpe Ratio and Value at Risk (VaR) for balancing risk and return.
  - Incorporating hedging strategies to protect against downside risks.

Real Optionality

- **Definition:** Real optionality refers to the flexibility embedded in real assets or investment decisions, often modeled similarly to financial options.
- **Examples:**
  - Decision to expand or delay a project.
  - Flexibility in production levels for a commodity.
  - Switching between energy sources based on cost and availability.
- **Key Characteristics:**
  - Value is derived from uncertainty in underlying variables (e.g., commodity prices, demand).
  - Often evaluated using option pricing models (e.g., Black-Scholes, binomial trees).
- **Importance in Commodities:**
  - Real optionality influences investment in infrastructure like storage facilities, pipelines, and power plants.
  - Provides competitive advantages in volatile markets.

Commodity Beta

- **Definition:** Commodity beta measures the sensitivity of a commodity's price to broader market movements or an index of commodities.
- **Formula:**

$$\beta_{\text{commodity}} = \frac{\text{Cov}(r_{\text{commodity}}, r_{\text{market}})}{\text{Var}(r_{\text{market}})}$$

- **Key Points:**
  - Indicates the systematic risk of the commodity.
  - Commodities with high beta are more volatile relative to the market, while low beta commodities are less correlated.
- **Application:**
  - Used to assess risk in commodity-based portfolios.
  - Helps in understanding how much of a commodity's return is driven by market-wide factors.

Commodity Alpha

- **Definition:** Commodity alpha measures the excess return of a commodity over its expected return based on market risks (beta).
- **Formula:**

$$\alpha = r_{\text{commodity}} - (\beta_{\text{commodity}} \cdot r_{\text{market}})$$

- **Key Characteristics:**
  - Represents the performance due to factors unique to the commodity.
  - Captures idiosyncratic factors like supply disruptions, technological changes, or geopolitical events.
- **Importance:**
  - A critical measure for active management in commodity markets.
  - Investors seek alpha through superior insights or strategies (e.g., anticipating weather patterns for agricultural commodities).
- **Contrast with Beta:**
  - Beta reflects systematic risk, while alpha captures unique opportunities or inefficiencies.

Comparing Real Optionality, Beta, and Alpha

- **Real Optionality:**
  - Focuses on the flexibility to adapt to market changes.
  - Long-term strategic value in commodities like storage or production flexibility.
- **Commodity Beta:**
  - Measures systematic risk and market sensitivity.
  - Useful for passive investment strategies.
- **Commodity Alpha:**
  - Measures unique, excess return unrelated to market movements.
  - Reflects active management or insights into commodity-specific factors.

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- Someone is still on the other side of the contract though. Who pays?

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- The exchange!– from exchange fees

Liquidation Engines in Commodity Markets

- Exchanges don't want to pay for overextension and sometimes can't
- This can lead to liquidity crises. Lots of crypto exchanges fail this way
- How to stop insolvencies?

Liquidity Engines

Overview:

- Traditional liquidity engines are mechanisms in financial markets designed to ensure smooth trading and prevent price volatility during high demand or supply periods.
- Widely used in stock exchanges, commodity markets, and centralized trading platforms.

Key Features Liquidity Engines

Key Features:

- **Order Matching Systems:**
  - Matches buy and sell orders in real-time based on price and priority.
  - Examples: Limit order books used by NYSE and NASDAQ.
- **Market Makers:**
  - Provide liquidity by continuously quoting buy and sell prices.
  - Profit from the bid-ask spread and reduce price gaps during low-volume periods.
- **Circuit Breakers:**
  - Automatically pause trading during extreme price swings to prevent panic selling or buying.
  - Examples: "Limit down" or "limit up" rules in futures markets.
- **Clearinghouses:**
  - Act as intermediaries to ensure that trades are settled and counterparties fulfill obligations.
  - Mitigate counterparty risk by holding margin accounts.

FTX was a liquidity engine failure

Figure 10: Who gave the man with the hair all that money?

The FTX Liquidity Engine

Overview:

- The FTX Liquidity Engine was a core feature of the FTX cryptocurrency exchange.
- Designed to maintain market stability and prevent cascading liquidations in volatile markets.
- Key tool for managing leveraged trading and margin positions.

FTX Liquidity Engine

Key Features:

- **Risk Management:**
  - FTX automatically monitors margin levels for all user accounts.
  - Positions that fall below the maintenance margin level are liquidated in small increments.
- **Backstop Liquidity Providers:**
  - Pre-approved liquidity providers step in to absorb liquidated positions, minimizing price slippage.
- **Cross-Margining:**
  - Allows traders to use the same collateral across multiple positions.
  - Reduces the risk of isolated liquidations during market volatility.
- **Clawback Prevention:**
  - The system was designed to prevent "socialized losses" by efficiently managing liquidation processes.

FTX Liquidity Failure

Why It Failed:

- **Excessive Risk-Taking:** FTX encouraged excessive leverage, amplifying systemic risks during market downturns.
- **Poor Risk Containment:** The engine could not handle extreme market volatility or the sudden collapse of large positions.
- **Backdoor Fraud:**
  - FTX secretly funneled customer funds to its sister firm, Alameda Research, undermining liquidity.
  - Alameda was treated preferentially, bypassing normal liquidation protocols and accessing unlimited credit.
- **Lack of Transparency:** Customers were unaware of how their funds were being used or the full extent of risk exposure.

Fraudulent Practices:

- Misappropriation of customer funds for speculative investments and personal benefits.

What is a commodity?

- Is Bitcoin a commodity? Who decides?

Figure 11: How's that HODL thing going for you?

Commodities vs. Securities

- Securities
  - Regulated by much more stringent Securities and Exchange Commission in NYC
  - According to SEC v. WJ Howey, a security exists when "a person invests his money in a common enterprise and is led to expect profits solely from the efforts of the promoter or a third party"
  - **The value of the security is based on someone's effort**
  - Equities and bonds
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  - Equities and bonds
  - Many crypto projects
- Commodities
  - Regulated by more free-market oriented Commodities Futures Trading Commission in Chicago
  - Common feature of commodities is interchangeability of a contract
  - Ag products, livestock, metals, energy
  - Swaps, commodity options
  - Most of crypto

Does Insider Trading Exist in Oil?

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- **This is not legal advice!!!**

Market Manipulation in Commodity Markets

- Market manipulation in commodity markets generally involves "non-economic trades"
- As a general rule, you should never purposefully lose money on one position in order to influence the price of another position
- Trades should either be hedges or stand on their own as speculation

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- As a general rule, you should never purposefully lose money on one position in order to influence the price of another position
- Trades should either be hedges or stand on their own as speculation
- Very difficult to prove "non-economic" trades
- What's the difference between stupid and illegal?

Gaming in Electricity Market

- The Federal Energy Regulatory Commission (FERC) defines gaming as 'behavior that circumvents or takes unfair advantage of Market Rules or conditions in a deceptive manner that harms the proper functioning of the market and potentially other market participants and consumers'
- The Ontario Market Surveillance Panel gives a four part test:
  - A defect or gap in the market design, rules or procedures governing the IESO administered markets (market defect)
  - Exploitation of the market defect by a market participant
  - Profit or benefit to the participant
  - Expense or disadvantage to the market

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- Above all gaming must be inconsistent with fundementals of supply and demand

How Hedging Works

- Traditionally, you hedge by buying (selling) a set amount of a physical commodity and selling (buying) an offsetting amount of the financial equivalent
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- The idea is to lock in a price and protect against price risk
- It doesn't have to be. Sometimes, you can make large revenues by making a directional bet on prices
- You do this by making the financial and physical position of different sizes

When Hedging Stops and Becomes Market Manipulation

- Trafigura bought physical oil in Louisiana to export to Singapore through the Platts Window
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- How to prove?

The Case of Enron

- Enron did a lot of illegal things. Very bad bookkeeping
- The company dramatically overstated revenues

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- Enron did a lot of illegal things. Very bad bookkeeping
- The company dramatically overstated revenues
- Enron also made a lot of money by manipulating the CAISO market

The Case of Enron

Code name	*Description*	*Result*
Ricochet	Exporting energy out of California's ISO's system, thus simultaneously avoiding price caps and decreasing supply, then reimporting it and selling it in the next day's (uncapped) real-time markets.	Artificially increased prices
Fat Boy	Deliberately overscheduling demand in the hour or day-ahead markets, generating a surplus that could then be sold in the uncapped real-time markets.	Artificially increased prices
Death Star	Scheduling a fictitious energy transmission in a loop that flows in the opposite direction to a congested transmission path, enabling collection of congestion relief revenues. Known variants on this strategy included Forney's Perpetual Loop and Driscoll's Death Star.	Activated congestion relief payments
Load Shift	Creating phantom demand for energy in order to change the market price and then buying or selling in that market at an advantageous rate.	Activated congestion relief payment, and artificially increased prices
Wheel-Out	Purposefully scheduling transmission on a path that was out of service, resulting in entitlement to congestion relief revenues.	Activated congestion relief payments
Get Shorty	Selling reserves in the day-ahead markets and then buying them in the cheaper real-time market.	Provided a (prohibited) arbitrage opportunity between markets

Figure 12: There was a Flaw in the Death Star.

Demand Response is a Lie!

MISO market participant Ketchup Caddy, CEO face $26.5M in fraud penalties

The company Ketchup Caddy LLC, originally founded to sell an in-car ketchup holder, and its CEO are facing $26.5 million in civil penalties after admitting to registering unknowing utility customers as demand response resources and offering their capacity into the Midcontinent ISO's capacity auctions even though it was never available.

Figure 13: Hold my Ketchup

Order Book in Commodity Markets: Overview

Definition: An order book is a real-time, continuously updated list of buy and sell orders in a market. It displays the number of contracts that buyers and sellers are willing to trade at different price levels.

Structure of the Order Book:

- **Bid Orders (Buy Orders):** Displayed on one side, representing the price and quantity buyers are willing to pay.
- **Ask Orders (Sell Orders):** Displayed on the other side, showing the price and quantity sellers are willing to accept.

Order Types:

- **Limit Orders:** Orders specifying the price at which a trader is willing to buy or sell.
- **Market Orders:** Orders to buy or sell immediately at the best available price.

Order Book in Commodity Markets: Mathematical Definition

Let:

- $B_i = (p_i, q_i)$: A bid order at price p_i with quantity q_i
- $A_j = (p_j, q_j)$: An ask order at price p_j with quantity q_j
- $\{B_1, B_2, \ldots, B_m\}$: Set of all bid orders, sorted by price from highest to lowest
- $\{A_1, A_2, \ldots, A_n\}$: Set of all ask orders, sorted by price from lowest to highest

Order Book Equilibrium

Order Book Function:

The order book can be represented by two functions, $B(p)$ and $A(p)$, which give the total quantity available at or above a bid price p or at or below an ask price p:

$$B(p) = \sum_{i:p_i \geq p} q_i \tag{1}$$

$$A(p) = \sum_{j:p_j \leq p} q_j \tag{2}$$

Market Equilibrium:

- The market reaches equilibrium when the highest bid $p_{\text{best\_bid}}$ equals or exceeds the lowest ask $p_{\text{best\_ask}}$.
- When $p_{\text{best\_bid}} \geq p_{\text{best\_ask}}$, a transaction occurs at a price between $p_{\text{best\_bid}}$ and $p_{\text{best\_ask}}$.

A Short Discussion of Prediction Markets

- Prediction markets used to be illegal because they are obviously gambling, and can influence real events
- The Supreme Court legalized prediction markets for US customers
- 2024 was the first time in history when a presidential election featured deep liquid prediction markets
- Why is this good?

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- The Supreme Court legalized prediction markets for US customers
- 2024 was the first time in history when a presidential election featured deep liquid prediction markets
- Why is this good?
- Why is this problematic?
- How should we interpret prediction markets?

Polymarket 2024 Odds

Figure 14: I wrote this slideshow before the election...

What is a Prediction Market?

Prediction markets are exchanges for buying and selling contracts on future events, with prices reflecting the likelihood of certain outcomes.

Mathematical Foundation:
Let P be the price of a contract that pays \$1 if an event E occurs. The price P reflects the collective probability p that E will occur, assuming efficient markets.

$$P \approx \mathbb{P}(E) = p \tag{3}$$

Market Participants:
Each participant i holds a belief p_i about the likelihood of E. They may buy or sell contracts based on the difference between p_i and the market price P.

- If $p_i > P$: participant believes E is more likely, leading to buying behavior.

Why market bids are not probabilities

- Take a sample prediction market where contracts trade between \$0 and \$100 with
- Costly arbitrage prevents markets from becoming perfectly efficient

Imagine a market with only pro-Kamala Investors

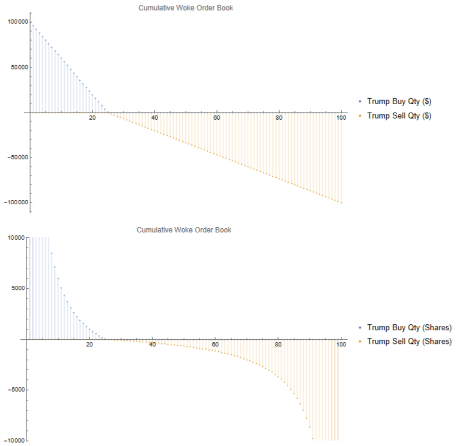

Figure 15: Pro-Kamala Order Book

Imagine a market with only pro-Trump Investors

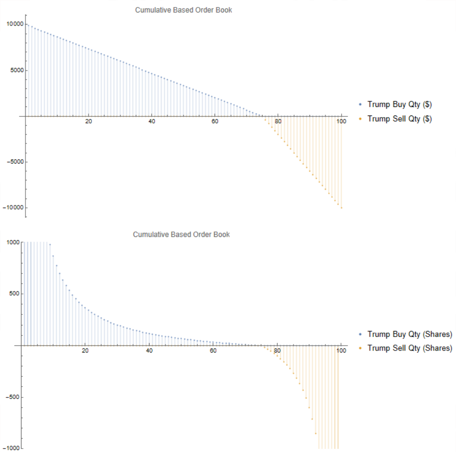

Figure 16: Pro-Trump Order Book

Mostly Kamala Some Trump

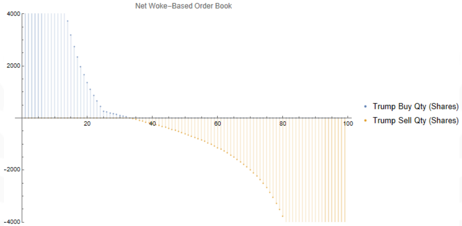

Figure 17: Adding a Few Trump Investors Moves the Kamala Market more

Thank You So Much!

List of References