



Science Job Shadow Program

With Quantitative Analytics Program



About me



Tell us about yourself:

- Name:
- Major and year:
- Favorite emoji:
- What did you do during the break?
- Why brings you to the program?
- Why do you expect to take away today?



Financial Markets and Financial Derivatives

An Introduction for Aspiring Quants

Jan 2, 2025

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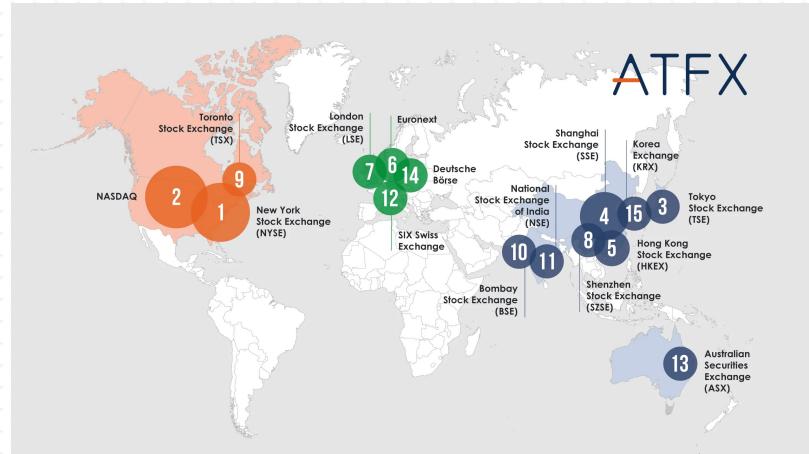
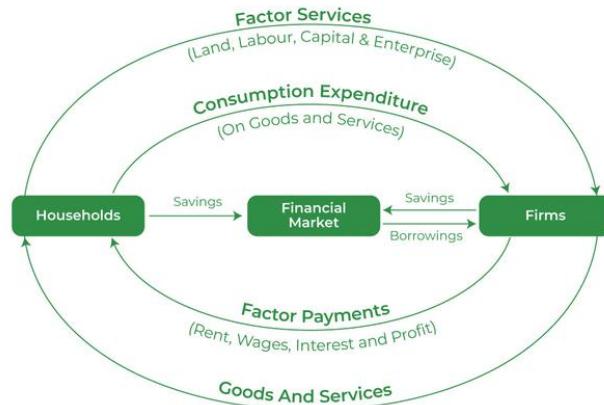
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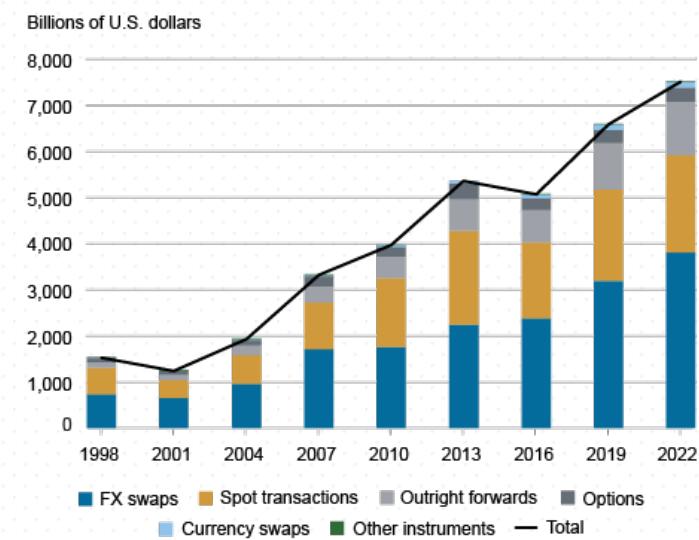
Financial Markets: The Engine of the Global Economy



Why Do Financial Markets Matter?

- Your money grows in markets through investments.
- Companies fund innovations by raising capital.
- Governments finance public projects via bonds.

Did You Know? The daily trading volume in FX markets exceeds \$7 trillion! 3rd economy behind US and China.



What role could YOU play in this dynamic system?



Your Role as Future Quants

Why Learn Quantitative Finance?

- Decode market behavior with math and data.
- Design strategies for trading, risk management, and beyond.
- Be part of the action in the financial world!



Types of Quants in Finance

Quant Traders

- **Role:** Develop and execute trading strategies to capitalize on market opportunities.
- **Skills Needed:**
 - Knowledge of financial markets and instruments.
 - Strong mathematical and statistical skills.
 - Proficiency in coding languages like Python or C++.
 - High adaptability and risk management abilities.

Quant Researchers

- **Role:** Conduct research to develop models and strategies for pricing, trading, or risk management.
- **Skills Needed:**
 - Advanced understanding of mathematical modeling and statistics.
 - Expertise in data analysis and machine learning.
 - Strong background in stochastic calculus and financial theory.
 - Ability to validate and test models effectively.

Quant Developers

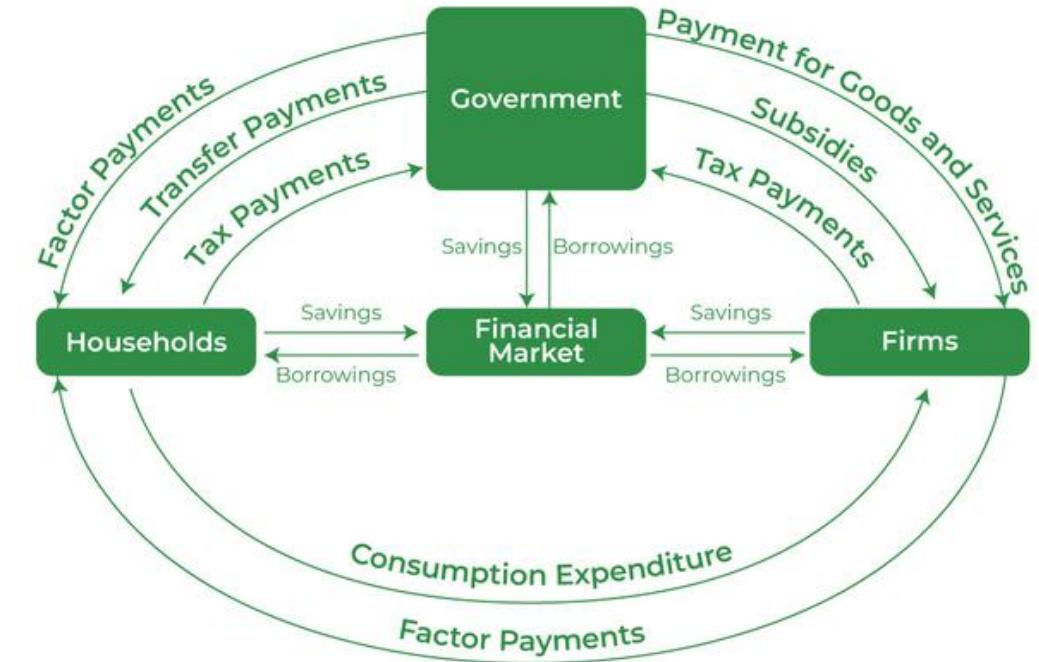
- **Role:** Build and maintain the infrastructure and tools used by traders and researchers.
- **Skills Needed:**
 - Expertise in software development and algorithm optimization.
 - Knowledge of database management and cloud computing.
 - Proficiency in multiple programming languages (e.g., Java, Python, C++).
 - Understanding of system architecture and high-frequency trading systems.



The Players

Three major players from a bird's-eye view:

- Business firms (net borrowers):
 - Raise capital now to pay for investments.
- Households (net savers):
 - Purchase securities issued by firms.
- Governments (can be both borrowers and savers):
 - Depends on the relationship between tax revenue and government expenditures.





The Players

Financial intermediaries: connectors of borrowers and lenders:

- Commercial banks
- Investment companies
- Insurance companies
- Pension funds
- Hedge funds
- Venture capital and private equity

DeFi: Decentralized Finance

Fintech and financial innovation:

- Peer-to-peer lending: LendingClub
- Broker: Robinhood
- Cryptocurrencies



Bitcoin Pizza Day: May 22



Categories of Financial Markets

- The money market: short term debt market, very liquid
- The capital markets:
 - longer term bond markets: Treasury bonds and notes, muni, corporate bonds, ABS
 - equity markets: stocks
 - the derivative markets: futures, options, etc
- Foreign exchange market: GBP, EUR, CAD, JPY, HKD, RUB, ZWL ...
- Commodities: crude oil, natural gas, electricity, carbon, metal, crops, weather ...



US Capital Markets

- NASDAQ
- NYSE
- CBOE
- CME: largest futures and options exchange in the US and the second-largest in the world

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What is a Derivative?

- An instrument whose value (or payoffs) is determined by, or is derived from, the value of another asset (underlying).
- Examples: futures, forwards, swaps, options, exotics...

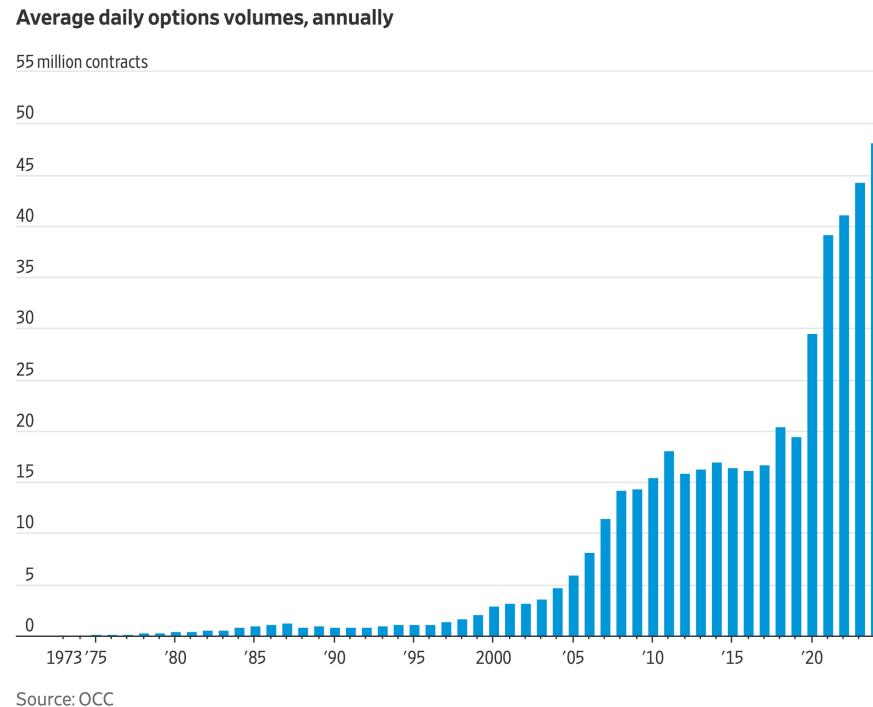


Exhibit 1: Single stock options trading volumes are bigger than shares volumes for the first time

Average daily notional traded for options vs the underlying stocks



Source: Goldman Sachs Global Investment Research, OptionMetrics, Data as of 21-July



Why Derivatives Are Important

- ➊ Derivatives play a key role in transferring risks in the economy
- ➋ The underlying assets include stocks, currencies, interest rates, commodities, debt instruments, electricity prices, insurance payouts, the weather, etc
- ➌ Many financial transactions have embedded derivatives
- ➍ The real options approach to assessing capital investment decisions has become widely accepted



How Derivatives Are Traded

- On exchanges such as the Chicago Board Options Exchange (CBOE)
- In the over-the-counter (OTC) market where traders working for banks, fund managers and corporate treasurers contact each other directly



The OTC Market Prior to 2008

- ➊ Largely unregulated
- ➋ Banks acted as market makers quoting bids and asks
- ➌ Master agreements usually defined how transactions between two parties would be handled
- ➍ But some transactions were cleared through central counterparties (CCPs). A CCP stands between the two sides to a transaction in the same way that an exchange does

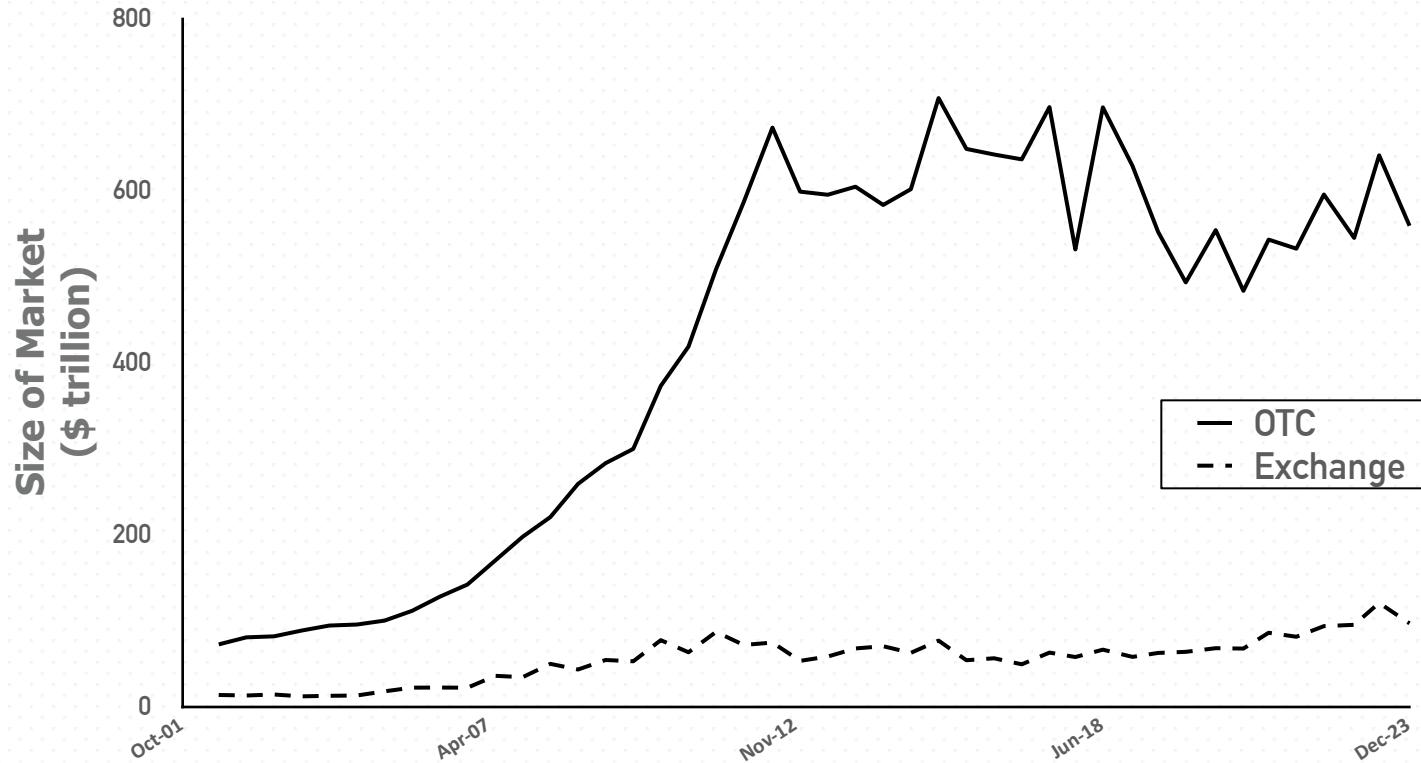


Since 2008...

- OTC market has become regulated. Objectives:
 - Reduce systemic risk: e.g. bank defaults ripple effect
 - Increase transparency
- In the U.S and some other countries, standardized OTC products must be traded on swap execution facilities (SEFs) which are electronic platforms similar to exchanges
- CCPs must be used to clear standardized transactions between financial institutions in most countries
- All trades must be reported to a central repository



Size of OTC and Exchange-Traded Markets



Source: Bank for International Settlements. Chart shows total principal amounts for OTC market and value of underlying assets for exchange market



The Lehman Bankruptcy

- ➊ Lehman's filed for bankruptcy on September 15, 2008. This was the biggest bankruptcy in US history
- ➋ Lehman was an active participant in the OTC derivatives markets and got into financial difficulties because it took high risks and found it was unable to roll over its short term funding
- ➌ It had hundreds of thousands of transactions outstanding with about 8,000 counterparties
- ➍ Unwinding these transactions has been challenging for both the Lehman liquidators and their counterparties



How Derivatives are Used

- ➊ To hedge risks
- ➋ To speculate (take a view on the future direction of the market)
- ➌ To lock in an arbitrage profit
- ➍ To change the nature of a liability
- ➎ To change the nature of an investment without incurring the costs of selling one portfolio and buying another

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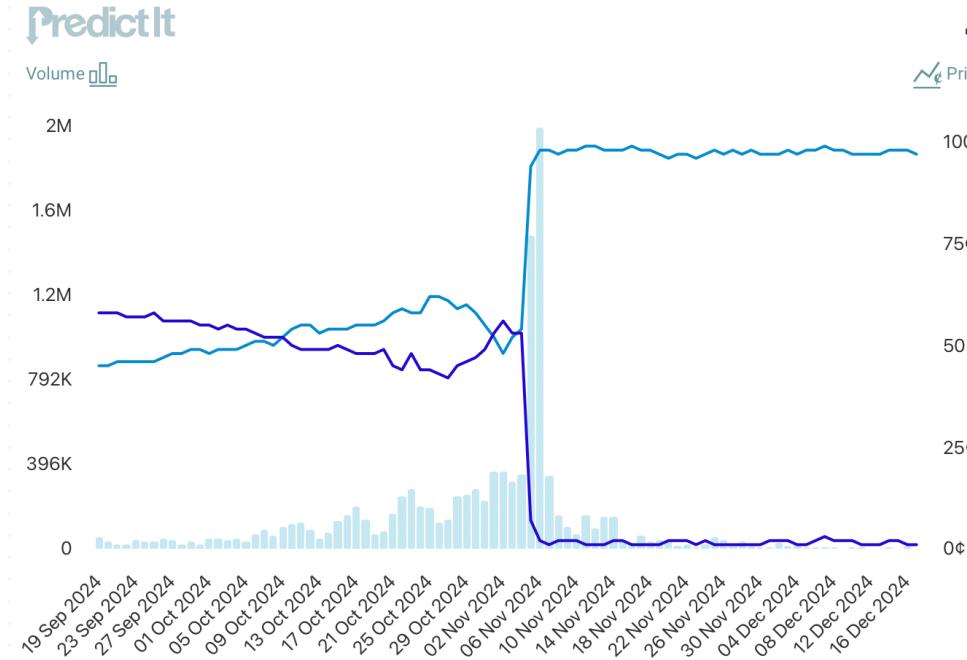
Forwards

- Scenario:
 - For a farmer growing wheat, revenue depends critically on the volatile crop price.
 - What could the farmer do to reduce risk (price volatility)?
- The miller:
 - Must purchase wheat for processing
 - Faces the mirror image problem of the farmer's
- Solution:
 - Enter a forward contract: the farmer to deliver the wheat when harvested at a price agreed upon now, regardless of the market price at harvest time
 - This contract is called a forward
- Outcome: the forward contract protects both the buyer and the seller from future price fluctuations



Futures

- Futures markets formalize and standardize forward contracting.
- Futures are traded in exchanges vs forwards in OTC
- Example: commodities, index, interest rate, FX, common stocks, presidential betting



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Options

- ➡ A call option: gives its holder the right to buy a certain asset by a certain date for a certain price (the strike price)
- ➡ A put option: gives its holder the right to sell a certain asset by a certain date for a certain price (the strike price)

Stock Options Volume Leaders

The highest option volume strikes showcase the most bought and sold options of the day.

Sat, Dec 28th, 2024 [Help](#)

STOCKS ETFS INDICES

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Symbol	Price~ Type	Strike	Exp Date	DTE	Bid	Ask	Last	Volume▼	Open Int	Vol/OI	Delta	IV	Last Trade	Links
+ NVDA	137.01 Call	138.00	01/03/25	6	2.17	2.20	2.18	87,786	7,146	12.28	0.45497	37.01%	12/27/24	:
+ NVDA	137.01 Call	140.00	01/03/25	6	1.35	1.38	1.36	87,567	50,951	1.72	0.33381	36.00%	12/27/24	:
+ NVDA	137.01 Call	140.00	01/24/25	27	5.20	5.30	5.25	73,431	18,087	4.06	0.46052	42.97%	12/27/24	:
+ NVDA	137.01 Call	144.00	01/03/25	6	0.45	0.47	0.46	60,649	11,990	5.06	0.14602	35.55%	12/27/24	:
+ NVDA	137.01 Call	142.00	01/03/25	6	0.81	0.82	0.81	43,929	36,909	1.19	0.22815	35.63%	12/27/24	:
+ NVDA	137.01 Call	145.00	01/03/25	6	0.34	0.35	0.34	40,996	30,571	1.34	0.11403	35.55%	12/27/24	:
+ NVDA	137.01 Call	136.00	01/03/25	6	3.20	3.30	3.20	39,691	7,011	5.66	0.57654	37.40%	12/27/24	:

Stock Option on MSFT

Premium:

the purchase price of the option.

represents the compensation call buyers pay for the right to exercise only when it is in their interest to do so.

Microsoft (MSFT)		Underlying Price: 295.71	
Expiration	Strike	Call	Put
1-Oct-2021	290	9.43	3.63
1-Oct-2021	300	3.60	7.82
1-Oct-2021	310	1.08	15.28
17-Dec-2021	290	17.25	11.72
17-Dec-2021	300	11.75	16.25
17-Dec-2021	310	7.62	22.05

Figure 20.1 Stock options on Microsoft,
September 10, 2021

Source: Yahoo! Finance.

Profit and Loss on a Call

- An October 1, 2021 call on MSFT with an exercise price of \$300 was selling on September 10 for \$3.60.
- Until the expiration date, the call holder can exercise the option to buy shares of Microsoft for \$300.
- On September 10, should the option holder exercise the option?
- On October 1, Microsoft sells for \$302, should the option holder exercise the option?

Value at expiration = Stock price – Exercise price = \$302 – \$300 = \$2

- What is the profit the holder realize?

Profit = Final value – Original investment = \$2.00 – \$3.60 = -\$1.60

- So the option holder should not exercise?

Microsoft (MSFT)		Underlying Price: 295.71	
Expiration	Strike	Call	Put
1-Oct-2021	290	9.43	3.63
1-Oct-2021	300	3.60	7.82
1-Oct-2021	310	1.08	15.28
17-Dec-2021	290	17.25	11.72
17-Dec-2021	300	11.75	16.25
17-Dec-2021	310	7.62	22.05

Figure 20.1 Stock options on Microsoft, September 10, 2021

Source: Yahoo! Finance.

Profit and Loss on a Put

- An October 1, 2021 put on MSFT with an exercise price of \$300 was selling on September 10 for \$7.82.
- Until the expiration date, the call holder can exercise the option to sell shares of Microsoft for \$300.
- On September 10, should the option holder exercise the option?
- On October 1, Microsoft sells for \$291, should the option holder exercise the option?

Value at expiration = Stock price – Exercise price = \$300 - \$291 = \$9

- What is the profit the holder realize?

Profit = Final value – Original investment = \$9.00 – \$7.82 = \$1.18

- How much does the other side of the transaction (option writer) make?

Microsoft (MSFT)		Underlying Price: 295.71	
Expiration	Strike	Call	Put
1-Oct-2021	290	9.43	3.63
1-Oct-2021	300	3.60	7.82
1-Oct-2021	310	1.08	15.28
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Figure 20.1 Stock options on Microsoft, September 10, 2021

Source: Yahoo! Finance.



American vs European Options

- ❖ American option: holder has the right to exercise the option **at any time** during its life.
- ❖ European option: holder has the right to exercise the option **only on the expiration date**.
- ❖ Most traded options in the US are American style. Exceptions: foreign currency options, some stock index options.



Other Listed Options

- Common stock options
- Index options
- Interest rate options
- Future options
- Swaptions = swap + options
- Foreign currency options
- Crypto options

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Types of Traders

-  Hedgers
-  Speculators
-  Arbitrageurs
-  Market makers / brokers

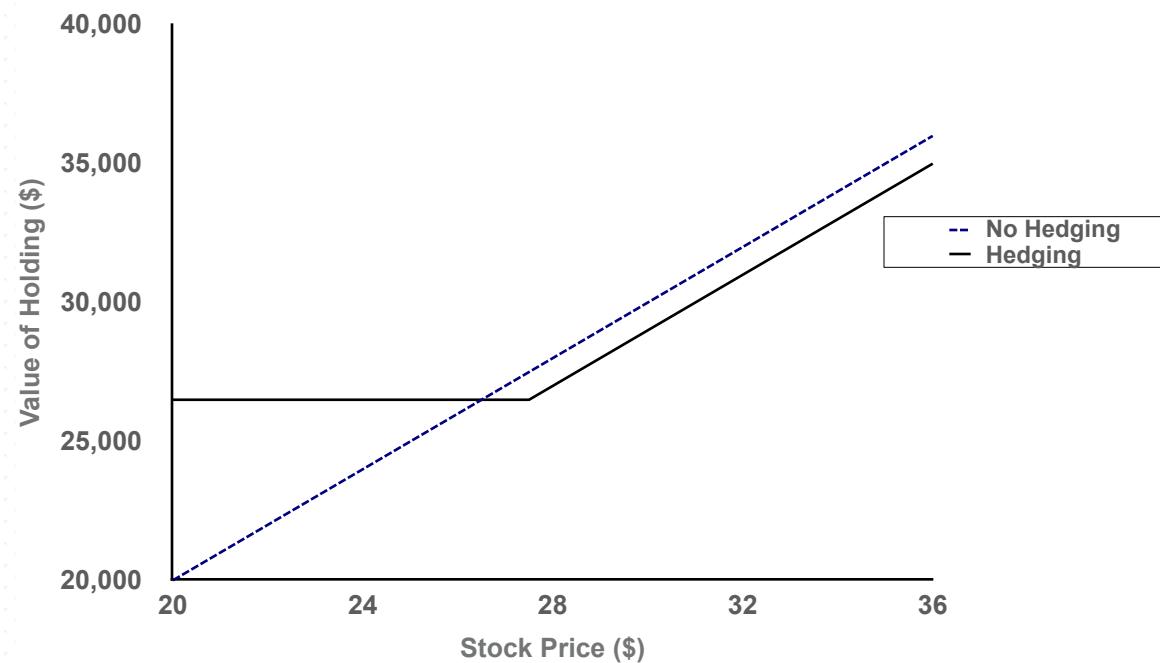


Hedging Examples

- ◆ A US company will pay £10 million for imports from Britain in 3 months and decides to hedge using a long position in a forward contract
- ◆ An investor owns 1,000 shares currently worth \$28 per share. A two-month put with a strike price of \$27.50 costs \$1. The investor decides to hedge by buying 10 contracts



Value of Shares with and without Hedging





Speculation Example

- An investor with \$2,000 to invest feels that a stock price will increase over the next 2 months. The current stock price is \$20 and the price of a 2-month call option with a strike of 22.50 is \$1
- What are the alternative strategies?



Arbitrage Example

- ➊ A stock price is quoted as £100 in London and \$120 in New York
- ➋ The current exchange rate is 1.2300
- ➌ What is the arbitrage opportunity?



Dangers

- ◆ Traders can switch from being hedgers to speculators or from being arbitrageurs to speculators
- ◆ It is important to set up controls to ensure that trades are using derivatives in for their intended purpose
- ◆ What can go wrong: SocGen's big loss in 2008.



Hedge Funds

- ➊ Hedge funds are not subject to the same rules as mutual funds and cannot offer their securities publicly.
- ➋ Mutual funds must
 - ▢ disclose investment policies,
 - ▢ make shares redeemable at any time,
 - ▢ limit use of leverage
- ➌ Hedge funds are not subject to these constraints.
- ➍ Hedge funds use complex trading strategies and are big users of derivatives for hedging, speculation and arbitrage



Examples of Hedge Fund Strategies

- Long/Short Equities
- Convertible Arbitrage
- Distressed Securities
- Emerging Markets
- Global Macro
- Merger Arbitrage



Takeaways

- 
- Capital markets overview
 - Derivative securities
 - Future and forwards
 - Options
 - Type of traders

Q&A



Reference

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