Introduction to Derivatives

MIT Sloan School of Management

Finance at MIT

Where ingenuity drives results

Introduction to derivatives

What is a derivative?

How are derivatives traded?

Why are derivatives useful?

What is a derivative?

Derivatives are securities whose future payoffs are tied by contract to some underlying variable. They are also called “contingent claims.”

The underlying variable is usually the price of a traded asset

equities	interest rates
currencies	commodities

- Interest rates are the largest derivatives asset class, followed by currencies

but it can also be a property of asset prices

volatility	max or min

or of corporate decisions

default events	level of dividends

or of other things

rainfall	inflation

What is a derivative?

Some derivatives are tied to two or more underlying variables such as difference between two reference prices

All of these variables have to be measurable and observable

The **basic types** of derivatives are:

forwards	futures
swaps	options
exotics	

The term “exotics” is an umbrella label for a broad range of derivatives that do not fit into the standard categories.

Forward contracts on box office revenues traded on hsx.com

The New York Times

Business; It's Just a Game, but Hollywood Is Paying Attention

By Norm Alster

Nov. 23, 2003

DAVE KILLINGSWORTH, 33 and a former disc jockey, is so immersed in pop culture that he has images of Spider-Man and Batman tattooed on his back. In his free time, he puts that passion to work betting in an online game, guessing which films will make it big. He is so good at forecasting the public's taste that he has reaped a windfall, at least in play dollars, turning $2 million into $460 million.

Mr. Killingsworth is one of a million people who have traded on the

These box office contracts are popular with film buffs that want to speculate on their ability to predict which films will be profitable and which will be flops. Similar contracts could be used to help film studios reduce the risk of uncertain revenues.

Where are derivatives found?

1. stand-alone instruments futures and options
2. corporate securities – warrants, employee stock options
3. embedded in other securities -- callable bonds, prepayable mortgages, convertible bonds, structured notes
4. Securitization

warrant: issued directly by the company, give the holder the right to buy shares of the corporation on some future date at a pre–specified price (option: the shares that fulfill the obligation are received from another investor not directly from the company)

employee stock option: a type of warrant granted to employees as part of their compensation packages

the owner of a callable bond has a claim that's equivalent to having a portfolio consisting of a regular bond plus a short position of a call option

Repayable mortgages which allow homeowners to pay back their mortgages prior to their maturity date also contain an embedded call option.

convertible bond has an embedded call option on a stock.

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4. Securitization

Securitization involves packaging together securities and then issuing claims that have promised payoffs that depend sometimes in complicated ways on the realized cash flows from the package of the underlying securities.

How is the outstanding supply determined?

- It's fixed for (2), (3), and (4), determined by issuer; supply doesn't change as people buy and sell them
- It's variable for (1), no fixed supply; anyone can enter either side of the market and buy or sell; if buyer and seller are both opening new positions, outstanding supply increases by one

the quantity of standalone derivatives is not constrained by the supply of the underlying asset or commodity that the contract's based on.

How are derivatives traded?

- Standalone derivatives are **traded in two forums**, **exchanges** and the **over-the-counter** (OTC) market.
  - Exchanges provide a central location, either physical or electronic, where people come together to buy or sell, and standardized contracts.
  - The over-the-counter market refers to bilateral trades, usually between large financial firms offering derivatives and the customers of these firms.

often other financial firms

- The OTC market is now the larger of the two, but exchanges provide important benefits, including greater safety from default risk and more transparent price discovery
- A recent trend is towards convergence between the two types of markets
- Regulators worldwide are forcing some OTC derivatives to be settled through clearinghouses like those used by exchanges
  - The clearinghouses are passive intermediaries that clear trades, enforce collateral requirements and serve as a guarantor of the transactions. Clearing effectively cancels out offsetting trades, reducing gross exposures.

Bob sells Miriam 1 0 futures contracts and Miriam sells Bob 7 of the same futures contracts.

risk exposures Clearing results in Bob having an obligation based on selling 3 contracts to Miriam. Without clearing, there would have been more risk exposure with the 1 7 outstanding contracts.

collateral now is often required in OTC markets, just as it always has been for exchange– traded instruments

The origins of derivatives

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Ancient History

- Farmers and merchants have used derivatives for thousands of years
- Evidence shows that forward contracts were used in 2000 B.C. in trade between India and the Arab Gulf
- In Ancient Greece, 300 B.C., olive growers used derivatives to reduce price risks associated with future harvests
- In the 12th century, merchants at European trade fairs negotiated forward contracts for the future delivery of their goods
- During Amsterdam's tulip mania in the 1630s, these financial instruments helped protect some merchants from price swings
- In the 17th century, Japan developed a forward market in rice

The origins of derivatives

More recent history of exchanges:

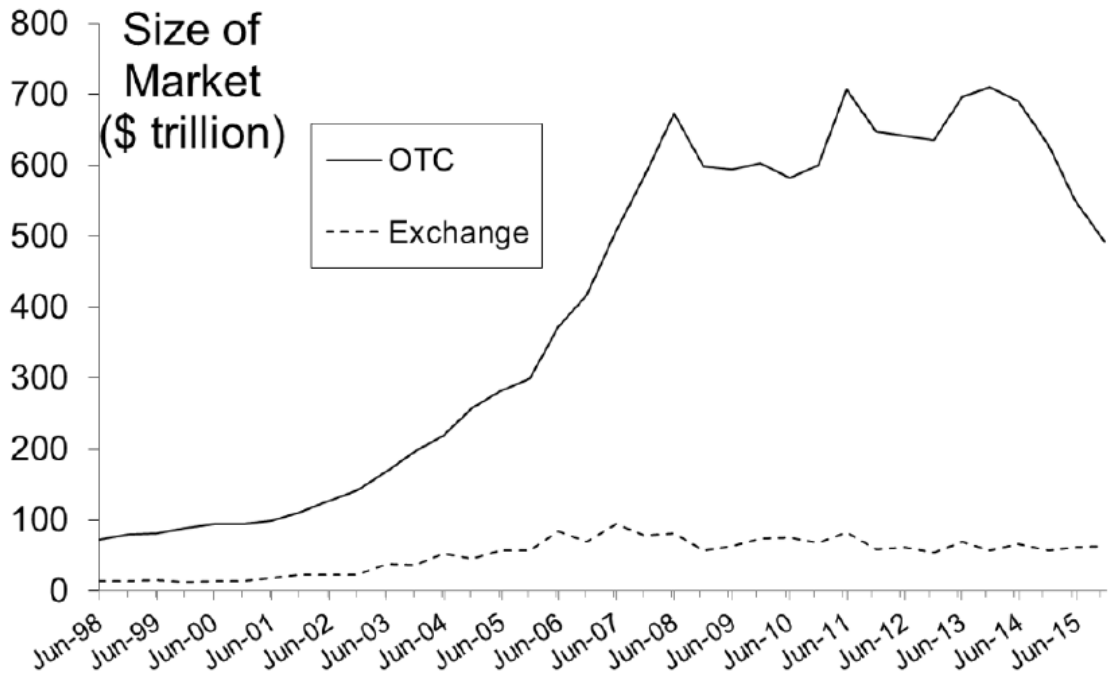
- Chicago Board of Trade (CBOT) was established in 1848: futures contracts
- Chicago Mercantile Exchange (CME) was created in 1919 (from Egg & Butter Board started 1898)
- CME and CBOT have merged to from CME Group that also include NYMEX and NEX (OTC)
- Chicago Board Options Exchange (CBOE) started trading standardized call options on 16 stocks in 1973
- Put options contracts started trading on CBOE in 1977.
- Nowadays CBOE trades options on thousands of stocks and many stock indices.
- Increasingly many competing exchanges, international reach (ICE, EUREX, Nasdaq…)
- Traditional open outcry system have now largely been replaced by electronic trading.

Old CME trading floor

Modern trading venue

Market statistics

Market size



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

- Data source for summary derivatives statistics is BIS. https://www.bis.org/statistics/about_derivatives_stats.htm?m=6%7C32

- What accounts for the falloff in the growth of the OTC market?
  - Effects of financial crisis
  - Effects of financial innovation

increased use of cleared contracts and the related phenomenon of compression. offsetting positions that have canceled out (Bob and Miriam)

Rapid growth starting in the 1970s. What triggered it?

Probably a combination of factors that include: deregulation, increased volatility, and technological innovation

Market prices more volatile → increased demand for risk management tools

(in part due to reduced regulation)

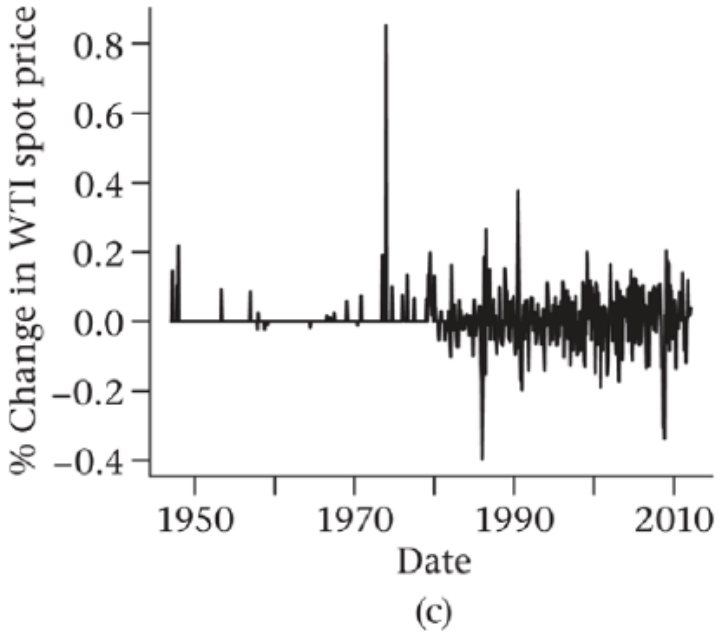
- Currencies were permitted to float in 1971. Currency futures started trading in 1972
- OPEC's 1973 reduction in the supply of oil was followed by high and variable oil prices
- U.S. interest rates became more volatile following inflation and recessions in 1970s
- Market for natural gas been deregulated since 1978
- The deregulation of electricity began during 1990s

Technological progress in the science of pricing derivatives, and in information technologies, increased market efficiency, making markets more attractive

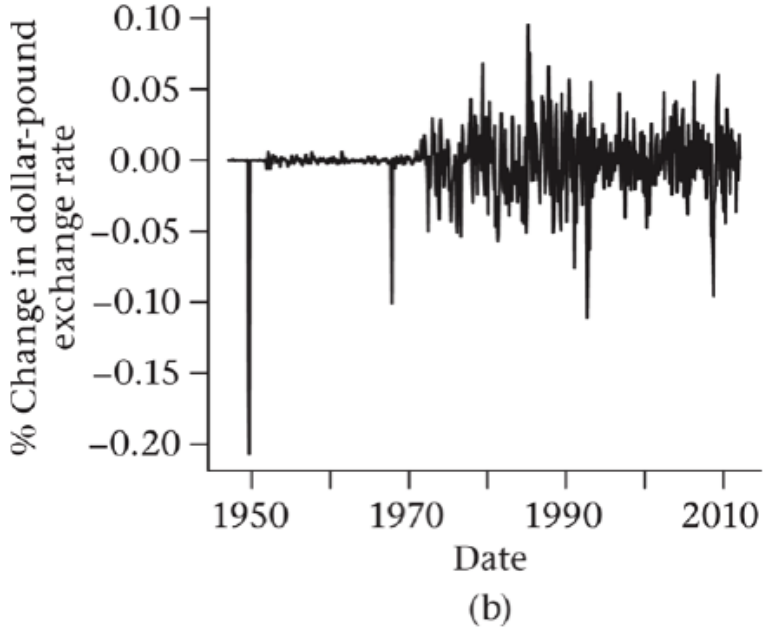
market efficiency and access

Explaining rapid market growth starting in the 1970s

- Oil prices: 1947–2011



- $/£ rate: 1947–2011



Sources: (a) St. Louis Fed; (b) DRI and St. Louis Fed; (c) St. Louis Fed; (d) CRB Yearbook.

There are many exchanges, but trading volume is highly concentrated on just a few

- There are over 100 exchanges in the world, for list see https://en.wikipedia.org/wiki/List_of_futures_exchanges
- Natural monopolies? How contestable are markets?

liquidity is enhanced if people are trading in the same contract. trading on the exchange that has the highest trading volumes, traders expect to obtain the best prices. They can also take advantage of collateral offsets.

Exchange-traded futures and options, by location of exchange

Notional principal, in billions of US dollars

« ‹ Q3 2019 › »	Open interest			Daily average turnover dollar volume of contracts traded						
Level: 1 2 3 4	Dec 2018	Jun 2019	Sep 2019	2017	2018	May 2019	Jun 2019	Jul 2019	Aug 2019	Sep 2019
⊟ Futures										
⊞ All markets	39,113	39,406	36,988	5,877	7,128	8,062	10,007	7,084	8,312	7,641
⊞ North America	26,752	27,099	25,993	3,952	4,879	6,220	7,562	5,145	6,383	5,561
⊞ Europe	9,785	8,980	8,118	1,636	1,926	1,454	1,978	1,630	1,571	1,682
⊞ Asia and Pacific	1,731	2,467	1,926	208	226	290	357	210	237	310
⊞ Other Markets	846	861	950	81	98	97	109	99	121	89
⊟ Options										
⊞ All markets	55,724	80,867	72,843	1,696	1,829	2,404	3,688	1,889	2,312	2,110
⊞ North America	42,090	66,130	55,518	1,413	1,491	2,173	3,299	1,566	1,972	1,595
⊞ Europe	13,116	13,730	16,415	260	316	199	333	285	310	487
⊞ Asia and Pacific	10	11	13	6	8	7	7	7	9	10
⊞ Other Markets	508	996	897	17	14	26	49	32	21	19

efficiencies from centralization make it difficult for new exchanges to compete with established venues.

Derivative market participants

End-users

foreign exchange

- Corporations: hedge a future cash flow (e.g., FX forward).
  - Used by > 94% of Fortune 500 companies for risk management
- Businesses: that sells production (buys input) at agreed forward price rather than (wait for) the uncertain future spot rate (e.g., orange producer)
- Financial institutions: manage interest rate, credit and other risks from the services they provide, and from mismatches between the assets and liabilities
- Hedge funds: low cost way to get in and out of asset classes

take highly leveraged positions (financial bet)

Intermediary: Market-Maker

help end users satisfy their demand for derivative products.

- Manages inventory, hedges risk, profits from fees and spreads

when they manage risk by derivatives. intermediary becomes end users

difference between bid and ask prices

Financial engineers: creating new derivative securities

- Facilitate hedging of existing positions
- Enable understanding of complex positions
- Allow for creation of customized products

Why are derivatives useful?

- Derivatives are a means to transfer risk from those that have it to those that are most willing to bear it
  - As such, derivatives excel as a tool for risk management
- Risk management is often about reducing risk, but it can also be about increasing attractive risks
- All of the derivative strategies that can be used to reduce risk can be reversed to increase risk
- Risk transfer via derivatives allows productive activities to be undertaken that otherwise might not be.
- There is also the potential for abuses, which regulations are designed to discourage

Example 1: Currency risk reduction for an exporter

The business:

A Swiss manufacturer of luxury watches agrees to deliver a shipment to a major U.S. retailer in December for the upcoming holiday season. The watchmaker and retailer have negotiated a payment of $10 million to be made to the watchmaker upon delivery

The problem:

- What if the U.S. dollar's value against the Swiss franc deteriorates and reduces profit for Swiss firm.
- **Can you find a way to eliminate the risk of exchange rate fluctuations?**

The solution:

- Enter into **a long position in December Swiss franc futures**, which will effectively lock in the exchange rate now for the USD payment due in the future

Example 2: Reducing risk of loss without realizing a capital gain

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The business:

- Alpha Asset Management has been investing in the stocks of a gold mining company for the last 5 years, and has an unrealized capital gain of $50 million.

The problem:

- For tax reasons, the fund does not want to sell its shares and realize the profits this year. However, it is concerned that the stock price might fall in the future
- **Can you find a way to "lock in" the profit without selling the shares?**

The solution:

- **Buy at-the-money put option on the stock**, which allows the fund to sell the shares at the current price in the event that the stock price falls in the future

Example 3: Hedging tracking error

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The business:

- You are the portfolio manager of an S&P500 index fund. You are evaluated based on the tracking errors — how closely your daily portfolio return tracks that of the index.

The problem:

- When markets become volatile, tracking the index becomes more difficult, and tracking errors tend to rise, which affects your performance
- **Is there a way to "insure" yourself against the risk of deteriorating tracking performance at times of high volatility?**

The solution:

- Enter into a **variance swap** on the S&P 500 index, which pays off when market volatility rises

Example 4: Speculating on a price drop--the big short

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The business:

- It is 2006. You believe that the housing market is overheated, and that a major correction in house prices will cause large amount of mortgage defaults, leading to big losses in subprime loans particularly

The problem:

- You can't short houses. Housing stocks can be costly to short, and their exposures might not be limited to subprime loans
- **How can you make a bet against the housing market at a large scale?**

The solution:

- John Paulson **shorted collateralized debt obligations**, whose performance depends on the performance of a pool of mortgage securities; he also **bought credit default swaps**, a contract that pays off when mortgage debt goes bad, and **sold short the ABX subprime index**

insurance

Derivatives trades can also be dangerous stunningly high losses

1993: Metallgeselschaft. Losses ~ $1.3 Bil.

- Oil futures

1994: Procter & Gamble. Losses ~ $ 200 Mil.

- Levered swap

1994: Orange County. Losses ~ $1.5 Bil.

- Interest rate mismatch

1995: Barings. Losses ~ $1.3 Bil.

- Short straddle on the Nikkei Futures

1998: LTCM. Losses ~ $3.5 Bil.

- Seller of liquidity

2006: Amaranth. Losses ~ $3 Bil

- Gas futures

2007-2009: Global Financial Crisis

- Enormous losses on Credit Derivatives and Structured CDOs

- Derivatives make it possible to take large and highly levered position quickly
- Risk may not be fully transparent; we will discuss how to recognize common hidden risks
- Adequate controls are an essential but not foolproof safeguard