FIN2010 Financial Management
Lecture 11: Financial Derivatives

Agenda

- What is a financial derivative?
- Why do we need derivatives?
- Commonly seen derivatives
  - Forward and futures
  - Options
  - Swaps
- Derivatives and the Great Financial Crisis

Learning Objectives

- Know the reasons why firms and investors need derivatives
- Understand the concept of forward, future, options, CDS
- Be able to calculate the payoff of forward, future, options

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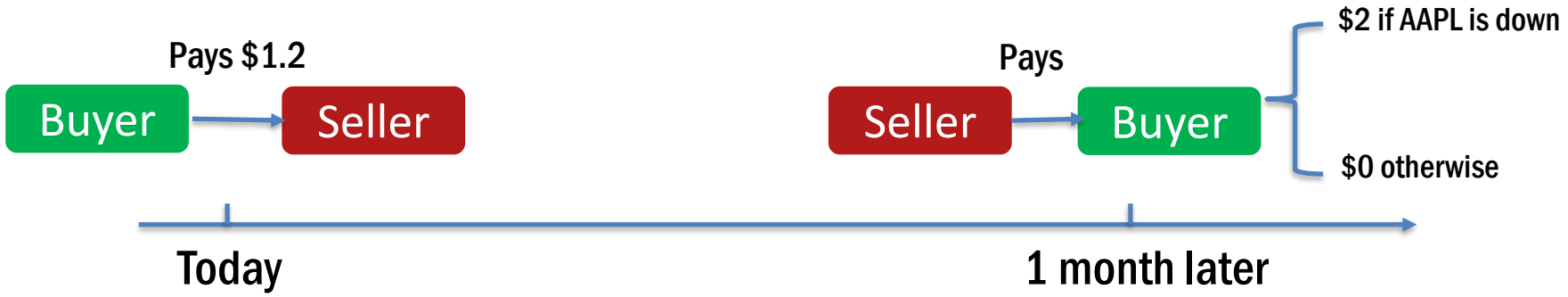
What is a Financial Derivative?

Derivative: a contract between two parties where payoff depends on the outcome of some underlying financial assets

- Example: a binary put option on AAPL:



- Expiration: 1 month
- Underlying asset: Apple's stock
- Payoff:
  - To buyer: 2 if AAPL is down, 0 otherwise
  - To seller: -2 if AAPL is down, 0 otherwise

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Uses of Derivatives

- Hedge: eliminate certain type of risks
  - E.g., a shoe factory in China sells shoes to the US. Costs are in CNY and revenue is in USD. The owner can hedge the exchange rate risk using futures contract.

- Speculate: profit from price movements
  - E.g., a fund manager believe house price will drop. However, he cannot sell short houses. He may use derivatives to gain exposure to house price.

- Align incentives: address the agency problem
  - E.g., employers often give workers the options to buy firm's stocks at a preset price. Thus the workers are incentivized to make the price higher than the preset price.

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Forward

- Goal: Locking in a price for a purchase to be made in the future
- Two parties sign a contract today that specifies
  - Underlying assets: the good (can be anything, like 10 tons of oil, $1M USD and so on) to be delivered in the future
  - Expiration date: the date of delivery
  - Future price: the price the buyer will pay in the future
- Example uses:
  - Farmers lock in the price of produces (e.g. corns) to be harvested in the future
  - Exporters lock in the exchange rate for payments they will receive later
  - Airline companies lock in the price for fuel in advance

Payoff of a Forward Contract

- Payoff: the benefit from having the contract

- Suppose currently the oil *spot price* (price for getting oil immediately) is $60 per barrel. Air China signs a forward contract with Goldman Sachs to buy 1000 barrels 6 months later at $60 per barrel.
  - If at expiration, oil price goes up to $65, who benefits?

    Payoff to buyer (Air China): + $5000
    Payoff to seller (Goldman Sachs): - $5000

- Price goes up → buyer benefits, seller loses
  - We say the buyer takes a long position in the forward contract, and the seller takes a short position

Forward Contract - Pros and Cons

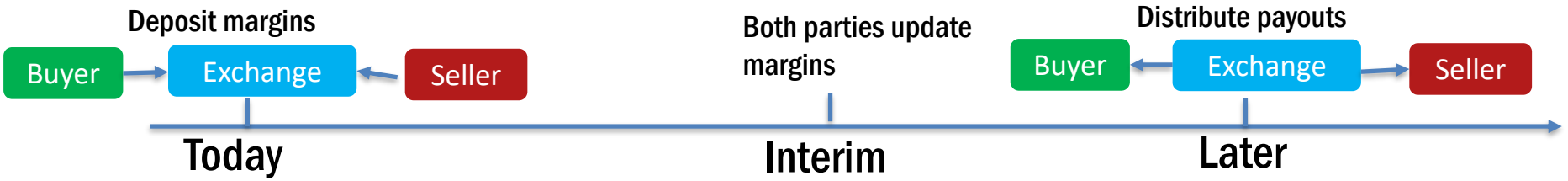
Pros:

- Flexible, allow users to lock price in advance

Cons:

- Higher counterparty risk
  - Counterparty risk: the other side may fail to deliver the fulfill their obligations. Potential reasons: they may go bankrupt, cannot obtain the goods to deliver (fail to harvest, etc.), or simply choose to default
- High liquidity risk: cannot easily get in or get out of a contract
  - For example, an oil company signed contract to sell oil at $35/barrel, but now the Middle East is in a war the oil price is rising all the way to $50. They would like to get out of the contract but cannot easily do it.

Future



- Goal: same as forward, to lock in a price for goods in advance
- Similar to forward, except that contracts are standardized, exchange-traded, and marked-to-market
  - Forward can be on anything, whereas future only cover a few specific products and have fixed size and limited expiration dates
  - Exchange trading reduces counterparty risk and increases liquidity (one can easily get out of a future contract). Example exchanges: CME, China Financial Futures Exchange, Shanghai Futures Exchange…
  - Buyers and sellers need to post and update margins
- Payouts can be either physical (e.g. commodities and FX) or in cash (e.g. S&P and interest rate)

Spot Price v.s. Future Price

- Spot price: the price if the product is to be delivered immediately
  - E.g., on 3/10/2020, the spot price of a commodity is $50. On 3/9/2020, the spot price of the commodity was $49.
- Future price: the price if the product is to be delivered in the future
  - E.g., on 3/10/2020, the future price (expiring on 5/31/2020) of the same commodity is $55. It means that, buyers are willing to pay $55 to buy the commodity in a month.
  - On 3/9/2020, the future price (expiring on 5/31/2020) of the same commodity was $45.
  - We will learn how to determine this price next time

How does Margin Work?

- Example: Crude Oil Future

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Oil Prices Collapse After Saudi Pledge to Boost Output

U.S. crude prices slid 25% to their lowest levels since 2016, after Saudi Arabian oil giant Aramco slashed prices and promised to increase output

On 3/9/2020, oil price plunged after Russia rejected a proposal by OPEC to cut its crude oil production by 1.5 million barrels a day and as retaliation, Saudi Arabian launched a price war.

Source:
https://www.wsj.com/articles/crude-prices-collapse-after-saudi-pledge-to-boost-output-11583748166
https://www.macrotrends.net/1369/crude-oil-price-history-chart

How does Margin Work?

Assume you plan to buy a future's contract on crude oil from CME and found out about the following information. How would margin work for you over time? CME: the world's largest financial derivatives exchange headquartered in Chicago.

CME Group MARKE

Exchange	Asset Class	Product	Product Code	Start Period	End Period	Maintenance	Maint. Vol. Scan
NYM	CRUDE OIL	CRUDE OIL FUTURE NYMEX	CL	02/2020	04/2020	3,500 USD	26.000%
NYM	CRUDE OIL	CRUDE OIL FUTURE NYMEX	CL	05/2020	05/2020	3,450 USD	22.000%

Month	Options	Charts	Last	Change	Prior Settle	Open	High	Low	Volume	Hi / Low Limit	Updated
APR 2020	OPT		34.31	-0.05	34.36	34.62	34.77	34.16	12,219	No Limit / 0.01	18:05:09 CT 10 Mar 2020
MAY 2020	OPT		34.70	-0.03	34.73	35.00	35.26	34.53	4,369	No Limit / 0.01	18:05:09 CT 10 Mar 2020
JUN 2020	OPT		35.22	+0.08	35.14	35.38	35.59	34.99	1,921	No Limit / 0.01	18:05:04 CT 10 Mar 2020
JUL 2020	OPT		35.72	+0.14	35.58	35.80	35.95	35.72	520	No Limit / 0.01	18:05:04 CT 10 Mar 2020
AUG 2020	OPT		36.46	+0.41	36.05	36.06	36.46	36.06	361	No Limit / 0.01	18:05:04 CT 10 Mar 2020

Source:
https://www.cme
crude_contract_s
https://www.cme
https://www.cme
crude_performance_bonds.html#pageNumber=1&sortField=exchange&sortAsc=true&clearing
Code=CL&sector=CRUDE+OIL&exchange=NYM
https://www.cmegroup.com/clearing/risk-management/performance-bonds-margins.html

Options Available Quarterly, Monthly, Weekly

- Speculative/non-member initial margin requirements for all products are set at 110% of the maintenance margin requirement for a given product.
- Hedger/member initial margin requirements for all products are set at 100% of the maintenance margin requirement for a given period.

How does Margin Work?

- On 3/10/2020, assume you buy a crude oil future's contract with an expiration date of 4/20/2020 at the closing price of $34.31 per barrel from CME.
- Each contract is 1000 barrels.
  - The buyer doesn't need to pay $ 34.31*1000 on 3/10/2020.
  - Instead, the buyer needs to deposit an initial margin of $3850 per contract or $3.85/barrel into the exchange. Same for the seller.
  - Initial margin: the amount of funds required to initiate a futures position. It varies from contract to contract and is determined by the exchange.

Updating Margin

- How should margin change when the future price changes?
  - Suppose the future price goes up by $1 on 3/11/2020

Date	**Price**	Buyer's Margin		Seller's Margin
3/10/2020	$34.31	$3850		$3850
3/11/2020	$35.31	$3850 + $1000	←	$3850 - $1000

  - The exchange transfers the money ($1000 in the example) from the seller's margin account to buyer's margin account to reflect the most up-to-date profit and loss
  - This is called marked-to-market

- Maintenance margin: the minimum amount that must be maintained at any given time in your account.
- Margin call: when the account balance drops below the maintenance margin, the trader needs to deposit more money
  - Otherwise, the position will be closed out by the exchange
  - In the case of CME, the maintenance margin is $3500. The seller needs to deposit another $650 to retain the position. Why? $2850+$650=$3500

Settlement at Expiration

- Now suppose the expiration date spot price is still $35.31
- At expiration, the buyer pays $35.31 per barrel to the seller, and gets 1000 barrels of crude oil
  - Note it's not the initial future price of $34.31
  - But the buyer gets some additional income from the margin account transfer.
- What is the cost of acquiring this 1000 barrels of crude oil? Has the buyer locked in a price of $34.31 per barrel?

Forward vs. Future

	Forward	Future
Who are involved?	Buyer signs contract directly with seller	Buyer and seller deal with an exchange
What can be negotiated?	Anything—extremely flexible	Exchange determines the underlying assets, contract size, and delivery dates
Capital commitment	None	Margin
Counterparty risk	High	None unless exchange fails
Liquidity	Poor	High

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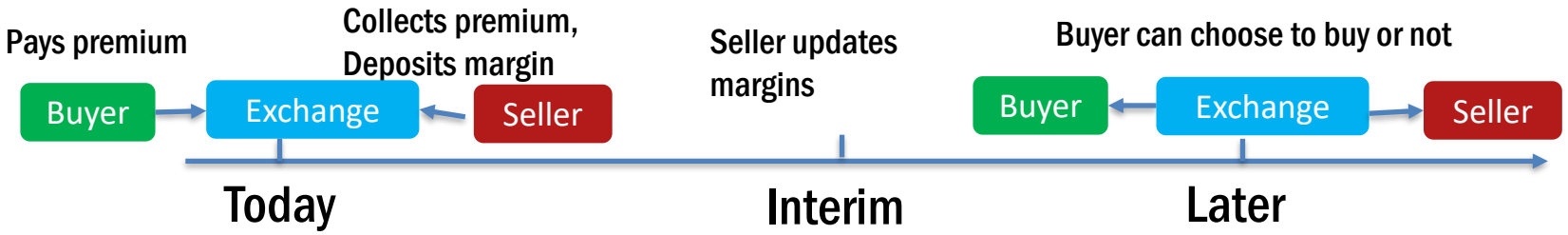
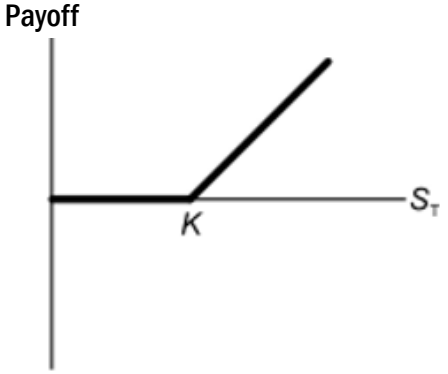
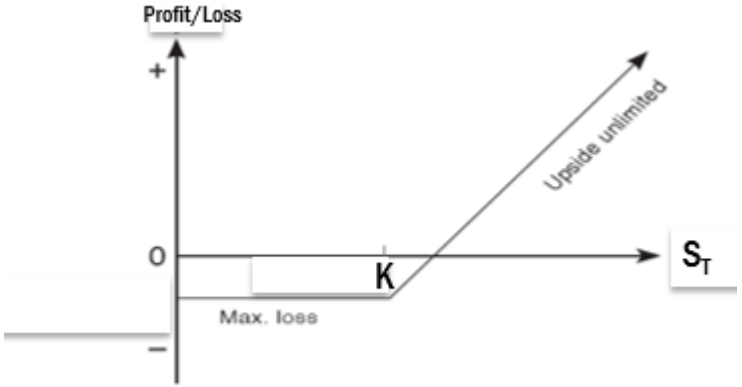
Call Option



- The buyer has the right, but not obligation, to **buy** an asset at a preset price (strike price (K)) on the maturity date
- Payoff and profit for buyer at expiration:

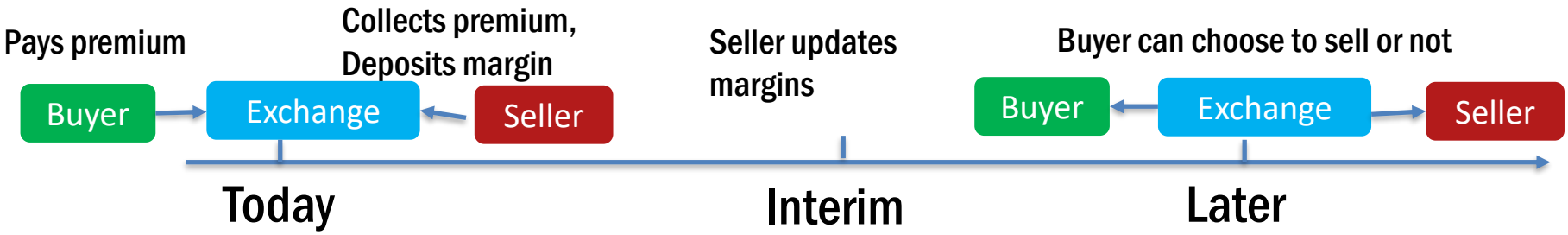




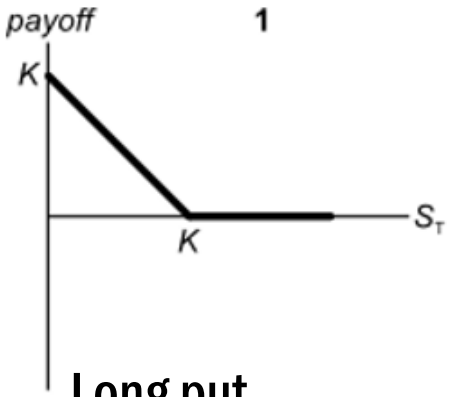
- What is the payoff and profit for seller?
- Why would someone want this payoff?

Notation:
K: strike price
S_T: spot price of the underlying stock on maturity date

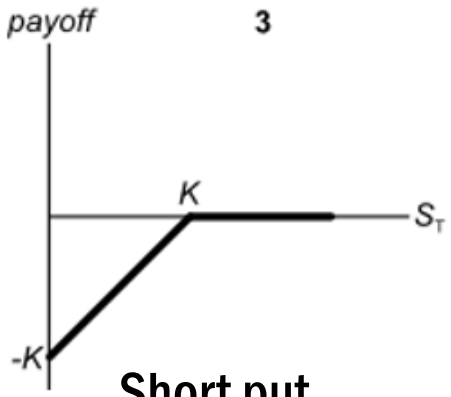
Put Option



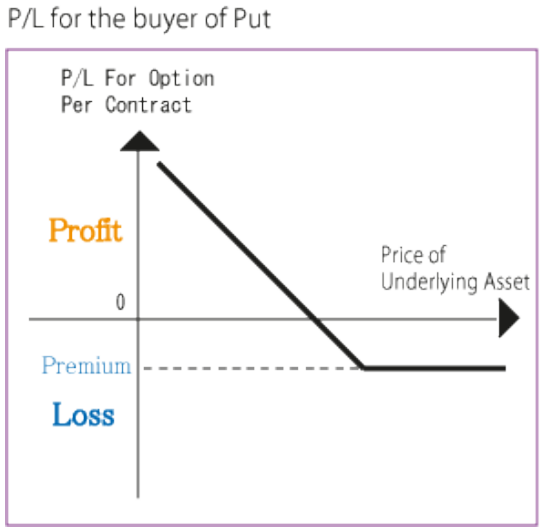
- The buyer has the right, but not obligation, to **sell** an asset at a preset price (strike price) on the maturity date
- Payoff and profit at expiration date shown below:

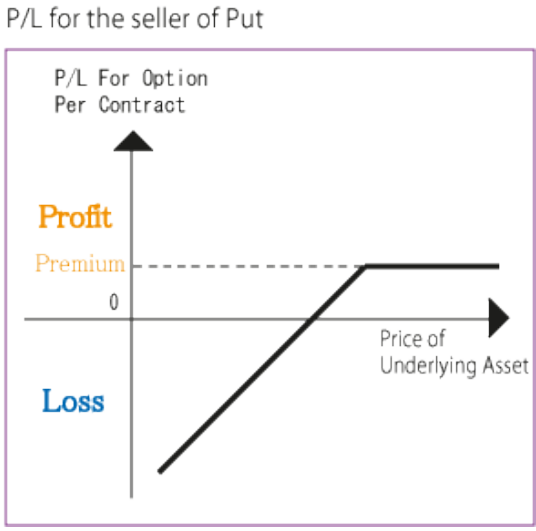


Long put (buyer of put option)



Short put (seller of put option)





Notation:
K: strike price; S_T: spot price of the underlying stock on maturity date; P/L: profit or loss

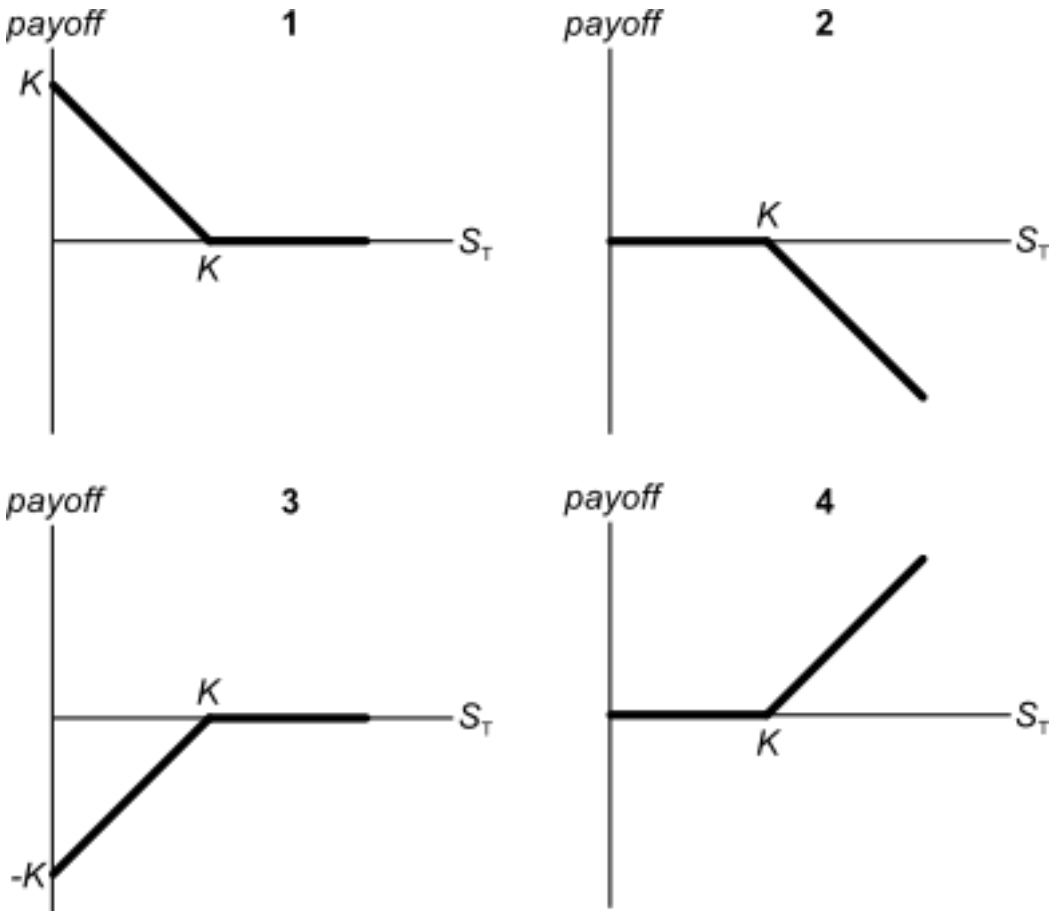
Option Payoffs—Exercise

1. Forward expires tomorrow and forward price is 97
2. The call and put options have strike price K=97, and expires tomorrow.

What is your payoff (that is, not the P/L) in each case?

S_t	Long forward	Short forward	Long call	Short call	Long Put	Short Put
96						
97						
98						

Can you Label the Positions?



- Long call – 4
- Short call 2
- Long put 1
- Short put 3

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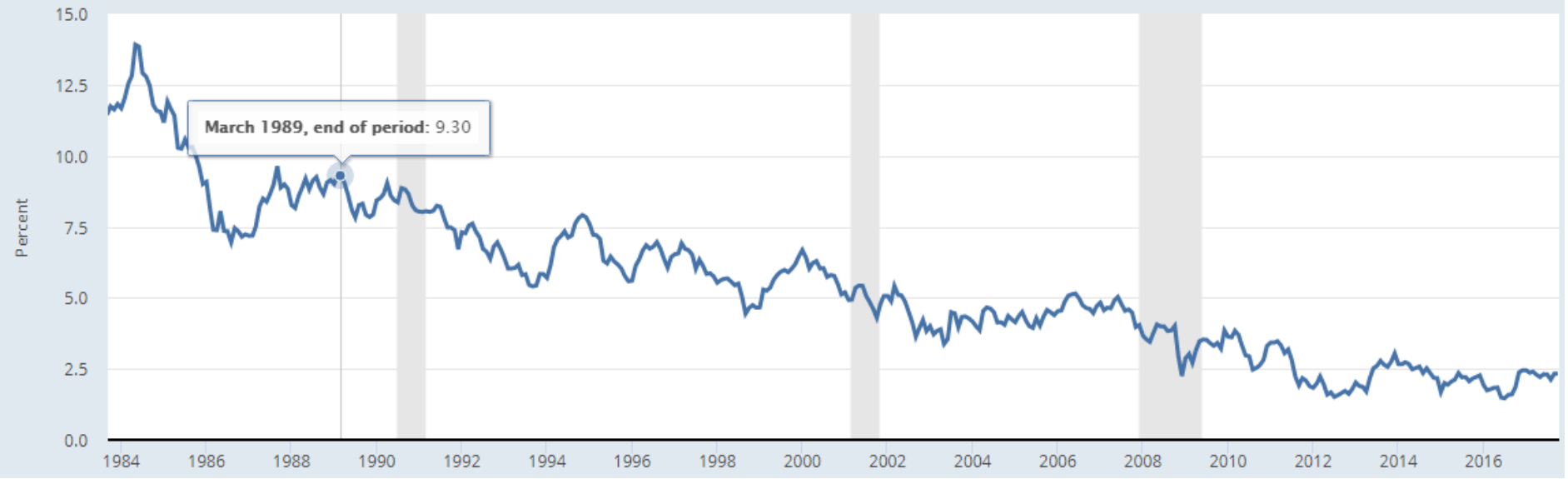
Swap

- Exchange two cash flows
  - Example: A pays B a fixed interest rate, B pays A a floating rate (based on some market rate)
- Why would anyone demand such a contract?
  - Interest rate swap: an insurance company needs to pay a fixed amount for claims every month. However, the income is highly tied to short-term interest rate because the company invests in short-term treasuries
  - Currency swap: Shell needs to pay its bond coupons denominated in British pounds, but it earns USD for selling oil products

The Toxic Swap Deal by Harvard Endowment

- In 2004, Harvard entered several interest rate swaps with about 3.7B in notional amount
  - Harvard pays fixed interest rates of about 4.5%
  - Harvard receives floating interest rate



- Harvard paid over 1.2B to get out of the deals because interest rate dropped

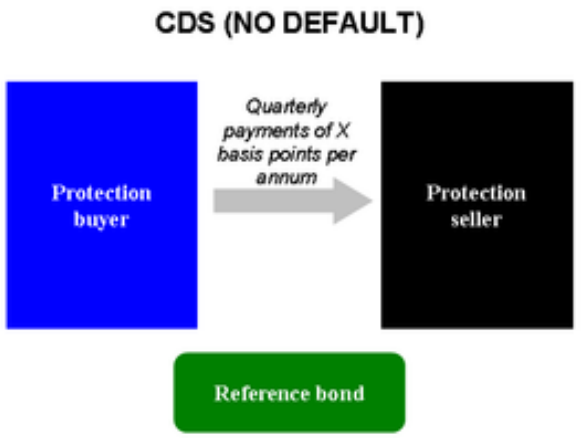
Why is the Loss So Large?

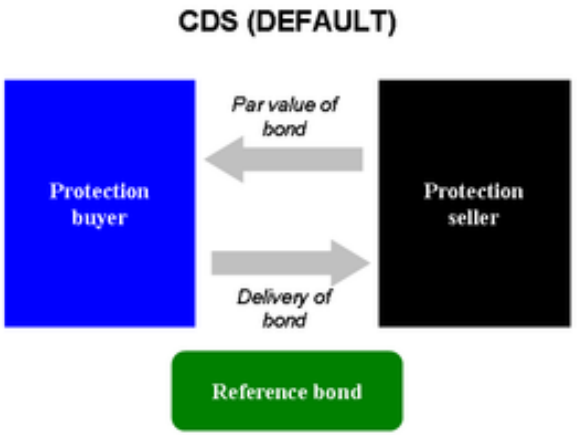
- Suppose the benchmark for floating interest rate is 1%. What is the present value of the loss assuming Harvard uses a discount rate of 8% per year?

$$PV(loss) = (4.5\% - 1\%) * 3.7B * \frac{1 - (1 + 8\%)^{-20}}{8\%} = 1.27B$$

Credit Default Swap (CDS) —an insurance on Bonds

- Underlying asset: bond or mortgage backed security
- Buyer pays seller payments (for protection) each period
- Seller gets the bond and pays buyer the par value if the bond issuer defaults, i.e. the buyer does not suffer at all in case of default





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Financial Crisis in 2008

- https://www.youtube.com/watch?v=bx_LWm6_6tA

A Test

- Can you fully understand what is going on in the clip from The Big Shorts?
- https://www.youtube.com/watch?v=Cxjdj5_5yNM

Next Lecture—Derivative Pricing

- Pricing by no arbitrage
- Forward and future pricing
  - Forward price
  - Carry
  - Future price
- Option pricing
  - Put-call parity
  - Binomial tree model
  - Black-Scholes-Merton model