Introduction to Financial Derivatives
Money, Banking and Financial Markets

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Outline

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Basic Notions in Derivatives

- Derivatives are financial securities that derive their value from an underlying asset, such as a stock, a bond or a currency.
- These contracts between two parties specify conditions (especially the dates, resulting values and definitions of the underlying variables, the parties' contractual obligations, and the notional amount) under which payments are to be made between the parties.
- Some of the more common derivatives include forwards, futures, options, swaps, and variations of these such as collateralized debt obligations (CDO), credit default swaps (CDS), and mortgage backed securities (MBS). In this lecture, we will study three most common derivatives: futures, options and swaps.

Basic Functions of Derivatives

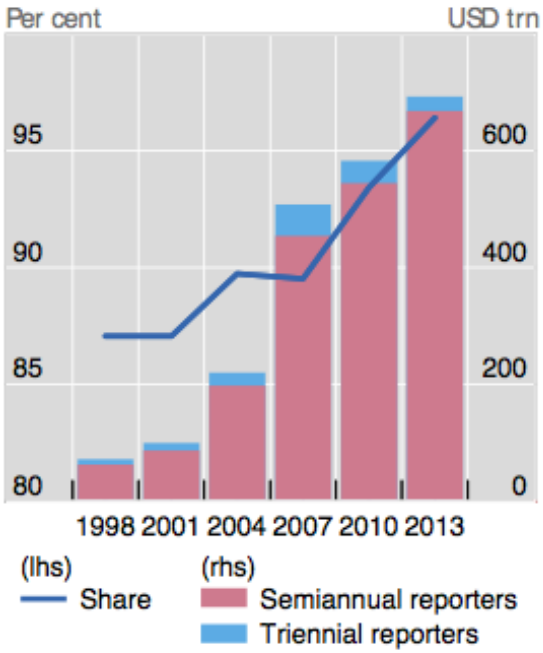
- An important use of derivatives is to hedge, or reduce risk. Typically, hedging involves the purchase of a derivative that increases in value if there is an adverse price change in the underlying asset in the derivatives contract.
- Investors can also use derivatives to speculate, or place financial bets on movements in asset prices.
- Speculators play two roles in the financial market: i) hedgers are able to transfer risk to speculators; ii) studies of derivatives markets have shown that speculators provide essential liquidity.
- Most derivatives are traded over-the-counter (OTC) or on an exchange such as the Chicago Mercantile Exchange (CME), while most insurance contracts have developed into a separate industry.

Global Derivatives Transaction Statistics: A Snapshot

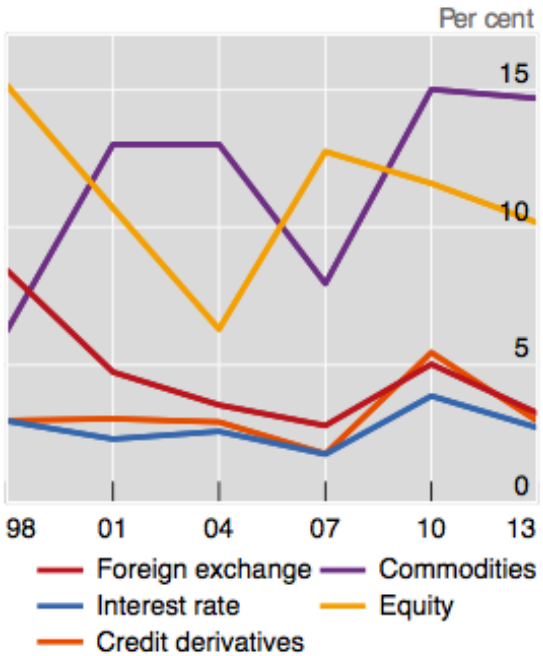
Global OTC derivatives market[1]

Graph 1

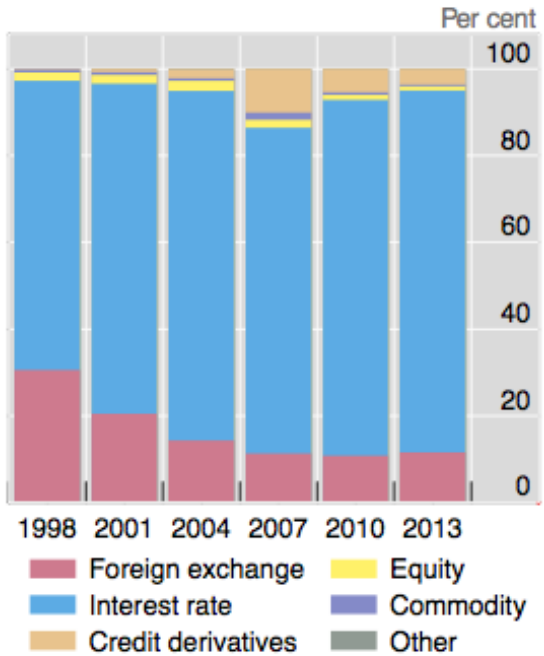
Notional amounts outstanding by sample of reporting institutions[2]



Gross market values as a share of notional amounts outstanding



Notional amounts outstanding by market risk category



[1] Adjusted for inter-dealer double-counting. [2] Share refers to the percentage of semiannual reporters in the global total.

Source: BIS Triennial Central Bank Survey.

Terminology in Trading and a Game (w)

- Hedge: to insure against risk of future price fluctuation, e.g., purchasing a derivative contract that will increase in value when another asset in an investor's portfolio decreases in value.
- Speculate: to place financial bets, as in buying or selling futures or option contracts, in an attempt to profit from movements in asset prices.
- A long position: the right and obligation of the buyer to receive or buy the underlying asset on the specified future date. In most case, the buyer expects future price will go up.
- A short position: the right and obligation of the seller to sell or deliver the underlying asset on the specified future date. In this case, the seller usually expects future price will go down.

Outline

Forward Contracts and its Origin

- The first futures exchange market was the Döjima Rice Exchange in Japan in the 1730s, to meet the needs of samurai who- being paid in rice, and after a series of bad harvests- needed a stable conversion to coin.
- In the United States, trading futures began in the mid-19th century with the establishment of central grain markets where farmers could sell their products either for immediate delivery, also called the spot or cash market, or for forward delivery.
- These forward contracts were private contracts between buyers and sellers and became the forerunner of today's exchange traded futures contracts.
- For a video course, check CME Education Webinar. (w)

Forward and Futures Contract: Definition

- Forward contract: A private, cash-market agreement between a buyer and seller for the future delivery of a commodity, at an agreed upon price. Forward contracts are not standardized and are non-transferable.
- Futures contracts: Standardized contracts for the purchase and sale of financial instruments or physical commodities for future delivery on a regulated commodity futures exchange.
- Problems with forward contracts: 1) not organized through an exchange; 2) consequently, no price transparency!; 3) double-coincidence-of-wants: need someone to take the opposite side!; 4) default risk of the counterparty.

Forward v.s. Futures Contract

- Both forward and futures contracts are legal agreements to buy or sell an asset on a specific date or during a specific month.
- Where forward contracts are negotiated directly between a buyer and a seller and settlement terms may vary from contract to contract, a futures contract is facilitated through a futures exchange and is standardized according to quality, quantity, delivery time and place.
- The only remaining variable is price, which is discovered through an auction-like process that occurs on the Exchange trading floor or via CME Globex, CME Group's electronic trading platform.

CME Real Time Futures Trading: A Snapshot (w)

Last Updated: 30 Dec 2014 08:38:51 CT

Agricultural

PRODUCT	LAST	CHANGE	CHART	GLOBEX VOL
ZCH5	409'4	-3'2		6,362
ZSH5	1048'4	-0'2		13,302
ZLH5	32.83	-0.10		6,164
ZMH5	357.7	-0.6		3,047
ZWH5	609'4	-6'0		3,277
LEG5	165.950	+0.950		1,782
HEG5	81.625 b	-0.175		410

Energy

PRODUCT	LAST	CHANGE	CHART	GLOBEX VOL
CLG5	53.72	+0.11		59,310
NGG5	3.090	-0.109		15,011
BZH5	58.44 a	-0.22		3,102
RBG5	1.4688	+0.0018		5,506
HOG5	1.8379	+0.0163		5,692
QMG5	53.700	+0.100		3,868
QGG5	3.090	-0.110		290

Interest Rates

PRODUCT	LAST	CHANGE	CHART	GLOBEX VOL
GEZ6	98.135	+0.04		26,667
ZQK5	99.835	+0.005		619
UBH5	165'07	+0'27		7,637
ZNH5	126'215	+0'090		161,106
ZBH5	144'18	+0'18		42,216
ZFH5	118'265	+0'057		89,546
ZTH5	109'092	+0'015		24,629

Equity

PRODUCT	LAST	CHANGE	CHART	GLOBEX VOL
ESH5	2079.25	-6.50		95,153
NDH5	4299.00	-12.00		17
YMH5	17931	-51		14,414
ENYH5	17240 a	-500		1
NKDH5	17345	-490		8,435
NQH5	4295.50	-15.50		18,053
SPH5	2078.90	-6.90		608

FX

PRODUCT	LAST	CHANGE	CHART	GLOBEX VOL
6AH5	0.8148	+0.0064		27,428
6CH5	0.8596	+0.0015		11,614
6SH5	1.0136	+0.0014		12,234
6EH5	1.2182	+0.0017		72,050
6BH5	1.5551 b	+0.0039		24,941
6JH5	0.008398	+0.000109		82,087
6MH5	0.067530	+0.000130		5,575

Metals

PRODUCT	LAST	CHANGE	CHART	GLOBEX VOL
GCG5	1197.9	+16.0		76,810
SIH5	16.035	+0.256		13,625
PLJ5	1209.0	+6.3		3,498
PAH5	811.20	-0.80		634
HGH5	2.8370	+0.0150		16,391
MGCG5	1197.9	+16.0		741
SILH5	16.040	+0.261		124

Mechanics of a Future Contract

1) Individuals open a margin account with a broker;
2) Enter into N futures contracts with price F_0;
3) Deposit initial margin: $5-10\%$ of contract value;
4) All profit/loss settled using margin account;
5) Margin call if balance is low.

- Pros: 1) high leverage, high profit; 2) very liquid; 3) a wide variety of underlying assets.
- Cons: 1) high leverage, high risk; 2) futures prices are approximately linear function of the underlying ? only linear payoffs can be hedged; 3) may not be flexible enough; back to Forwards!

Futures Contract – Market Practices

- Margin requirement is the minimum deposit that an exchange requires from the buyer or seller of a financial asset. (Initial margin, maintenance margin, variation margin)
- Marking to market is a daily settlement in which the exchange transfers funds from a buyer's account to a seller's account or vice versa, depending on changes in the price of the contract.
- Daily settlement: futures contracts are marked-to-market on a daily basis; daily price limits restrict the maximum daily price movements.
- Price limits are set based on the previous day's settlement price. These limits are set by the Exchange and help to regulate dramatic price swings.

Hedging with Futures: Example

- Suppose you plant wheat in May with the expectation that it will yield 10,000 bushels of wheat in August.
- The spot price of wheat is $2.00 per bushel, and you are concerned that the wheat price will fall below $2.00 in August.
- A manager at General Mills, which buys wheat to produce cereal, is concerned that in August the price of wheat will rise above $2.00.
- In the futures market for wheat, you can take a short position and the General Mills manager can take a long position.
- Hedging involves taking a short position in the futures market to offset a long position in the spot market or vice versa.

Outline

Option Contracts Terminology

An option is a security that **gives the holder the right** to buy (call) or to sell (put) an underlying asset on or before a particular date for a predetermined price. Correspondingly, the option **writer has the obligation**. Basic elements of an option:

- Two types of option: Call v.s. Put.
- Two types of trader: Buyer (holder) v.s. Seller (writer)
- Two types of position: Long (buy) v.s. Short (sell)
- Two prices: Spot v.s. Strike (exercise)
- Expiration (maturity) date: the holder can exercise on or before the date. (European v.s. American)
- Option fee (premium): the price of the option contract. The holder pays to the writer. (Tradable before maturity)

CME Real Time Option Trading: A Snapshot (w)

Options Product Slate

Top 10 | Agriculture | Energy | Equity Index | FX | Interest Rates | Metals | View All Options Products

Clearing	CME Globex	Floor	CME ClearPort	Product Name	Sub Group	Exchange	Volume	Open Interest
ES	ES	-	ES	E-mini S&P 500 Options	US Index	CME	219,802	2,116,833
LO	LO	LO	LO	Crude Oil Options	Crude Oil	NYMEX	121,838	2,723,556
21	OZN	TC / TP	21	10-Year T-Note Options	US Treasury	CBOT	117,776	3,033,692
E0	GE0	E0	E0	Eurodollar 1yr MC Options	Stirs	CME	67,632	4,946,896
ED	GE	CE / PE	ED	Eurodollar Options	Stirs	CME	66,256	15,824,359
17	OZB	CG / PG	17	U.S. Treasury Bond Options	US Treasury	CBOT	64,406	340,179
25	OZF	FL / FP	25	5-Year T-Note Options	US Treasury	CBOT	55,419	628,056
S	OZS	CZ / PZ	S	Soybean Options	Grain And Oilseed	CBOT	47,553	676,046
LN	LNE	LN	LN	Natural Gas Options (European)	Natural Gas	NYMEX	40,183	3,704,499
EW	EW	-	-	E-mini S&P 500 EOM Options	US Index	CME	38,502	589,568

Most Active Options Products at CME

- Agriculture: Cheese, Corn, Feeder Cattle, Lean Hogs, Live Cattle, Class III Milk , Lumber, Oats, Soybeans (Meal and Oil), Wheat.
- Energy: Ethanol, Heating Oil, Light Sweet Crude Oil, Natural Gas, RBOB Gasoline, Brent Crude Oil
- Equity Index: S&P 500 (E-mini), NASDAQ 100 (E-mini), Nikkei 225
- FX: Australian Dollar, British Pound, Canadian Dollar, Euro, Japanese Yen, New Zealand Dollar, Swiss Franc
- Interest Rates: Eurodollar Mid-Curves 30-Day Fed Funds, 2-, 5-, and 10-Year Note, U.S. T-Bond, Ultra T-Bond
- Metals: Copper, Gold, Palladium, Platinum, Silver Real Estate: S&P/Case-Shiller Home Price Index
- Weather: Frost, Hurricane, Rainfall, Snowfall, Temperature

Example: Stock Option

On March 15, 2015, the Google Inc. is \$480 per share. Suppose you buy a call option on a share of google stock for \$10. The option will expire on June 14, 2015 with a strike price of \$490 per share. Bonus Questions:

1) Find out all the basic elements of such an option.

2) Under what conditions you will make or lose money?

3) Can you consider all possible scenarios and draw a payoff graph?

4) How does the option writer's (counterparty) payoff look like?

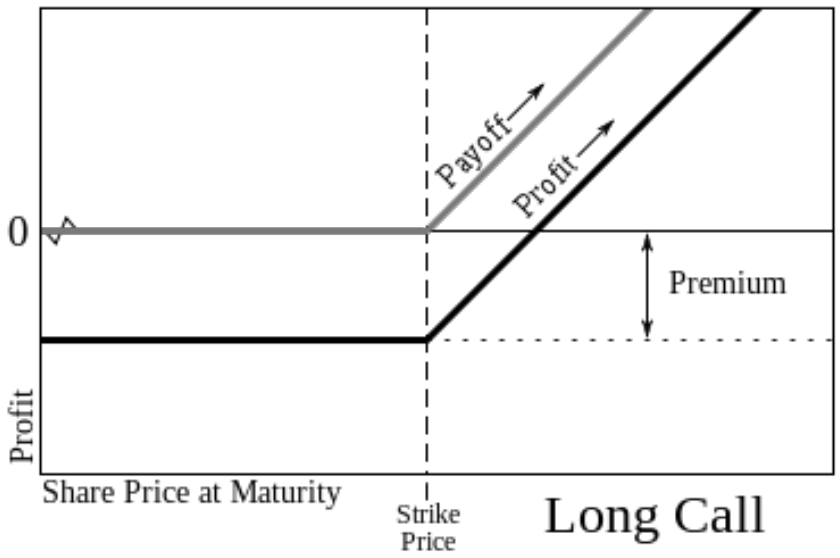
Option Payoff Schemes: Notations

Call option fee paid at time 0 — C_0
Put option fee paid at time 0 — P_0
Strike Price of the asset on or before expiration date — K
Spot Price of the asset at any time before expiration — S_t
The option is said to have intrinsic value if its payoff is positive.

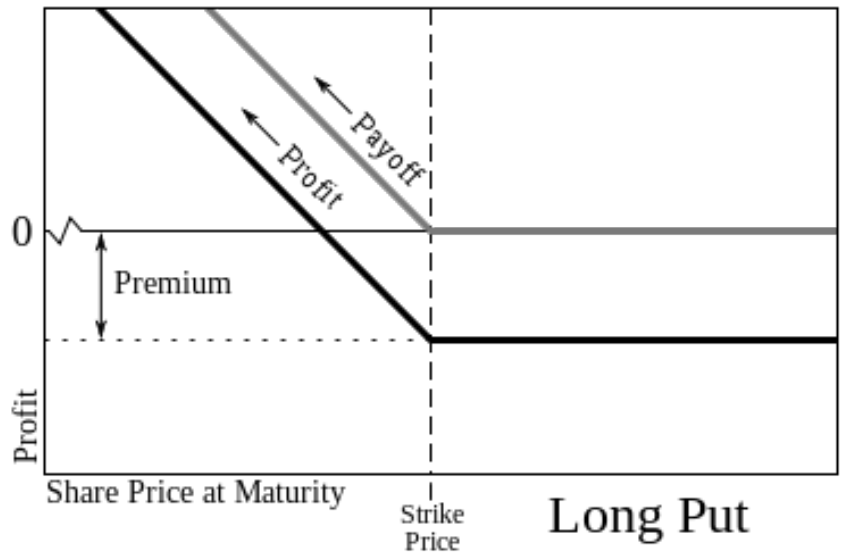
- Long Call (buyer of a call option) Payoff: $max(S_t - K, 0) - C_0$
- Long Put (buyer of a put option) Payoff: $max(K - S_t, 0) - P_0$
- Short Call (seller of a call option) Payoff: $C_0 - max(S_t - K, 0)$
- Short Put (seller of a put option) Payoff: $P_0 - max(K - S_t, 0)$

Option Payoff: Long Positions (Holder's Right)

Long Call: $max(S_t - K, 0) - C_0$



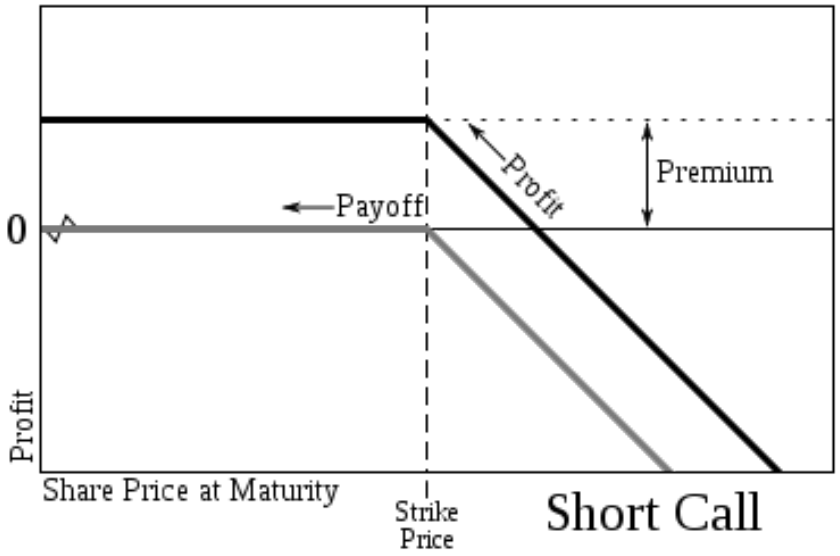
Long Put: $max(K - S_t, 0) - P_0$



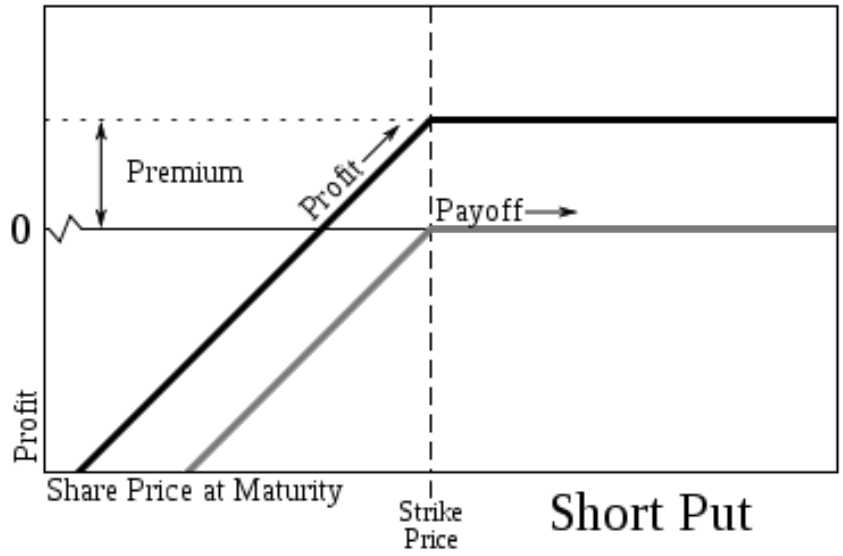
- "Long" wisdom: Heads, I win; Tails, I don't lose too badly!
- What are the heads here? And tails?

Option Payoff: Short Positions (Writer's Obligation)

Short Call: $C_0 - max(S_t - K, 0)$



Short Put: $P_0 - max(K - S_t, 0)$



- "Short" wisdom: Heads, I win a little; Tails, I could lose badly!
- What are the heads here? And the tails?

Option Pricing Techniques

- The tough question for traders: how much is the option?
  a) spot price S_t; b) strike price K; c) time to maturity T;
  d) interest rate r; and most importantly e) !?!
- The binomial option pricing model: equivalence of pricing by state prices and risk-neutral prices.
- The Black-Scholes pricing formula (european option)
  $C = SN(d_1) - Ke^{-rT}N(d_2)$ where
  $d_1 = \frac{ln(S/K)+(r+\sigma^2/2)T}{\sigma\sqrt{T}}$ and $d_2 = d_1 - \sigma\sqrt{T}$.
  $P = Ke^{-rT}N(-d_2) - SN(-d_1)$.
- The idea of dynamic hedging: form a portfolio, e.g. stock + option + bond, that is always arbitrage free.
- How to calculate the volatility σ? Historical v.s. Implied

Outline

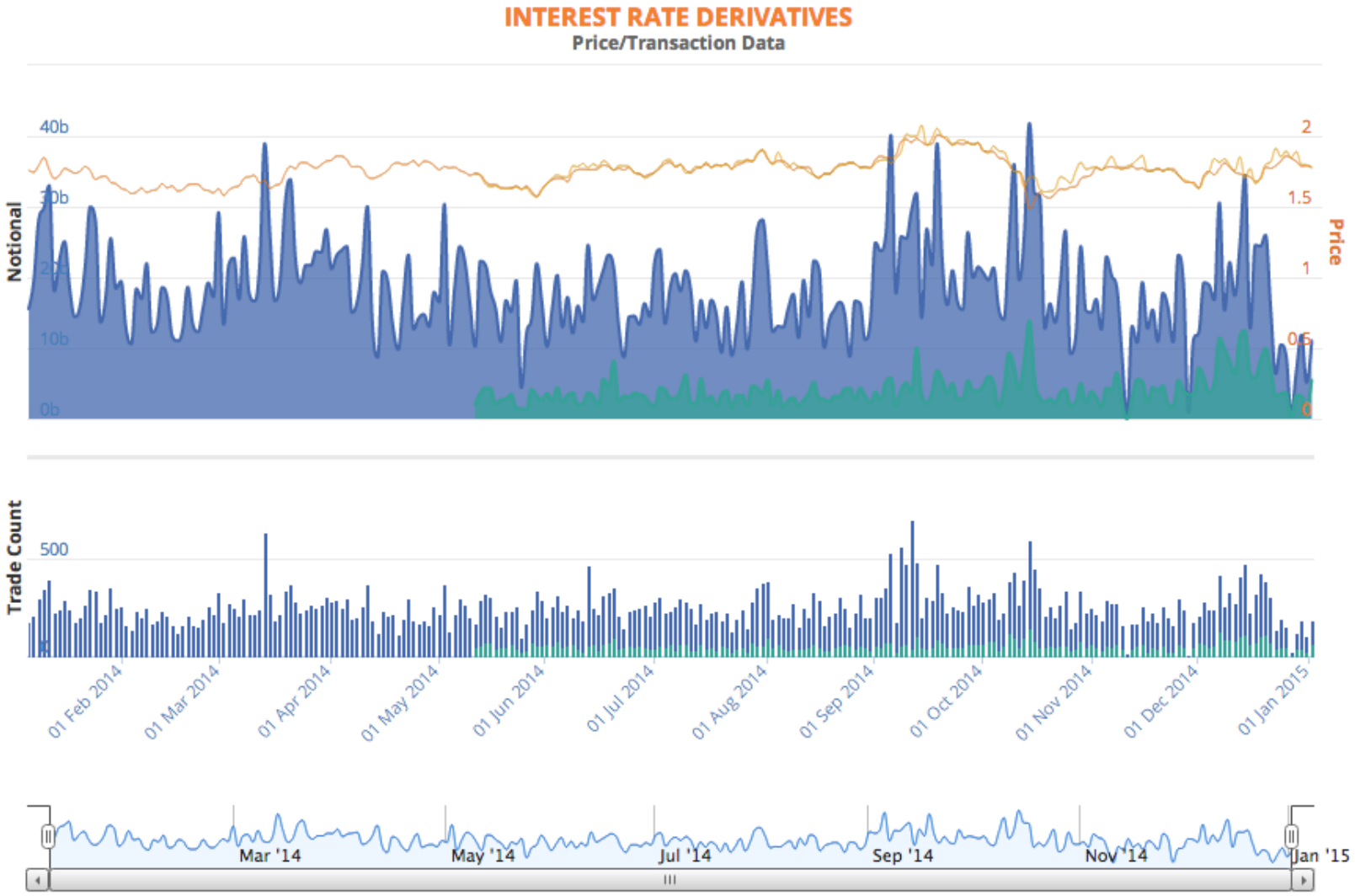
Swaps Market

- A swap is a derivative in which two counterparties exchange cash flows of one party's financial instrument for those of the other party's financial instrument.
- The cash flows are calculated over a notional principal amount. Contrary to a future, a forward or an option, the notional amount is usually not exchanged between counterparties. Consequently, swaps can be in cash or collateral.
- For example, in the case of a swap involving two bonds, the benefits in question can be the periodic interest (coupon) payments associated with such bonds.
- The five generic types of swaps, in order of their quantitative importance, are: interest rate swaps, currency swaps, credit swaps, commodity swaps and equity swaps.

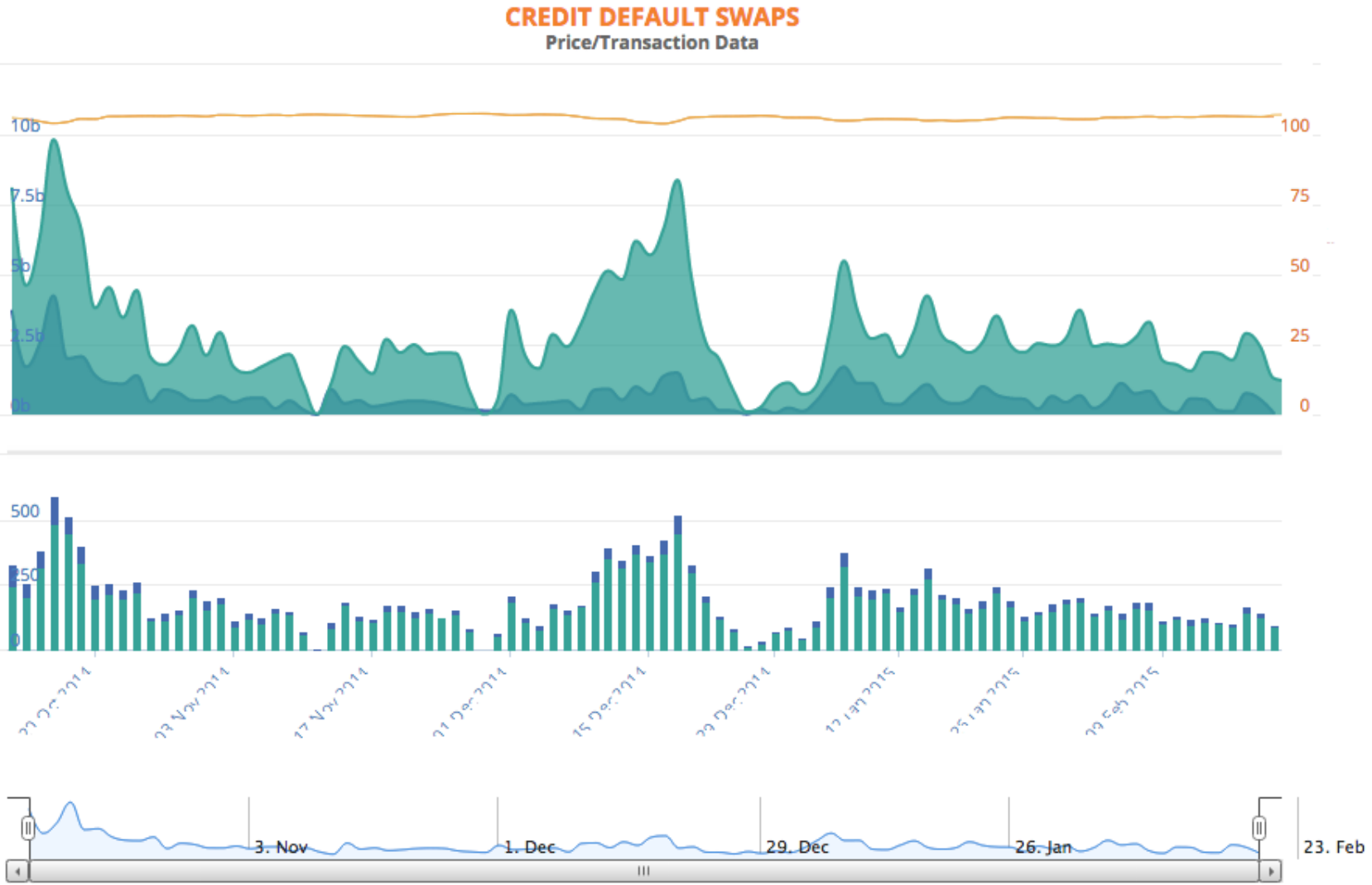
Swaps Contracts

- Most swaps are traded over-the-counter (OTC), "tailor-made" for the counterparties. Some can be traded on futures markets (CME).
- Why swaps? 1) change the nature of cash flows; 2) leverage strengths in different markets.
- Plain vanilla swap: fixed interest rate v.s. floating interest rate.
- Commodity swaps: exchange floating price for a fixed price (e.g. gold swaps, oil swaps).
- Currency swaps: exchange principal and fixed rate interest payments on a loan in one currency with another.
- Credit Default Swaps: A bilateral contract involving a protection buyer and a protection seller. The buyer seeks "protection" from the seller against the default of an underlying reference entity (e.g. a corporate bond), and in return for the protection services, the buyer pays a periodic sum of premium to the protection seller.

Real Time Transaction: Interest Rate Derivatives (w)



Real Time Transaction: Credit Default Swaps (w)



Example: Interest Rate Swaps

ABC Bank and XYZ Insurance Company both want to borrow \$100 million for five years. ABC Bank can borrow fixed rate at 7.5% and floating rate at $LIBOR + 1\%$, XYZ Insurance Company can borrow fixed rate at 6% and floating rate at $LIBOR + 0.5\%$.

1) Key question: How to swap both parties better off?

2) Which company has absolute advantage at borrowing?

3) Which company has comparative advantage in fixed rate?

Example: Interest Rate Swaps...cont'd

ABC Bank and XYZ Insurance Company both want to borrow \$100 million for five years. ABC Bank can borrow fixed rate at 7.5% and floating rate at $LIBOR + 1\%$, XYZ Insurance Company can borrow fixed rate at 6% and floating rate at $LIBOR + 0.5\%$.

4) Consider the following cash flow pattern for each party:

ABC Bank Cash Flows	XYZ Insurance Cash Flow
1. Pay $LIBOR + 1\%$ to its lender	1. Pay 6% to its lender
2. Pay 6% fixed rate to XYZ	2. Pay *LIBOR* to ABC
3. Receive *LIBOR* from XYZ	3. Receive 6% from ABC

Example: Swaps Benefits and Cost...cont'd

5) What are the net gains from the swaps to each party?

Cost and Benefit	ABC Bank	XYZ Insurance
Fixed Rate	7.5%	6%
Floating Rate	$LIBOR + 1\%$	$LIBOR + 0.5\%$
Absolute Advantage	Neither	Both
Comparative Advantage	$LIBOR + 1\%$	Fixed rate 6%
Swap Arrangement Cost	$6\% + 1\% = 7\%$	$LIBOR$
Net Gain from Swap	0.5%	0.5%

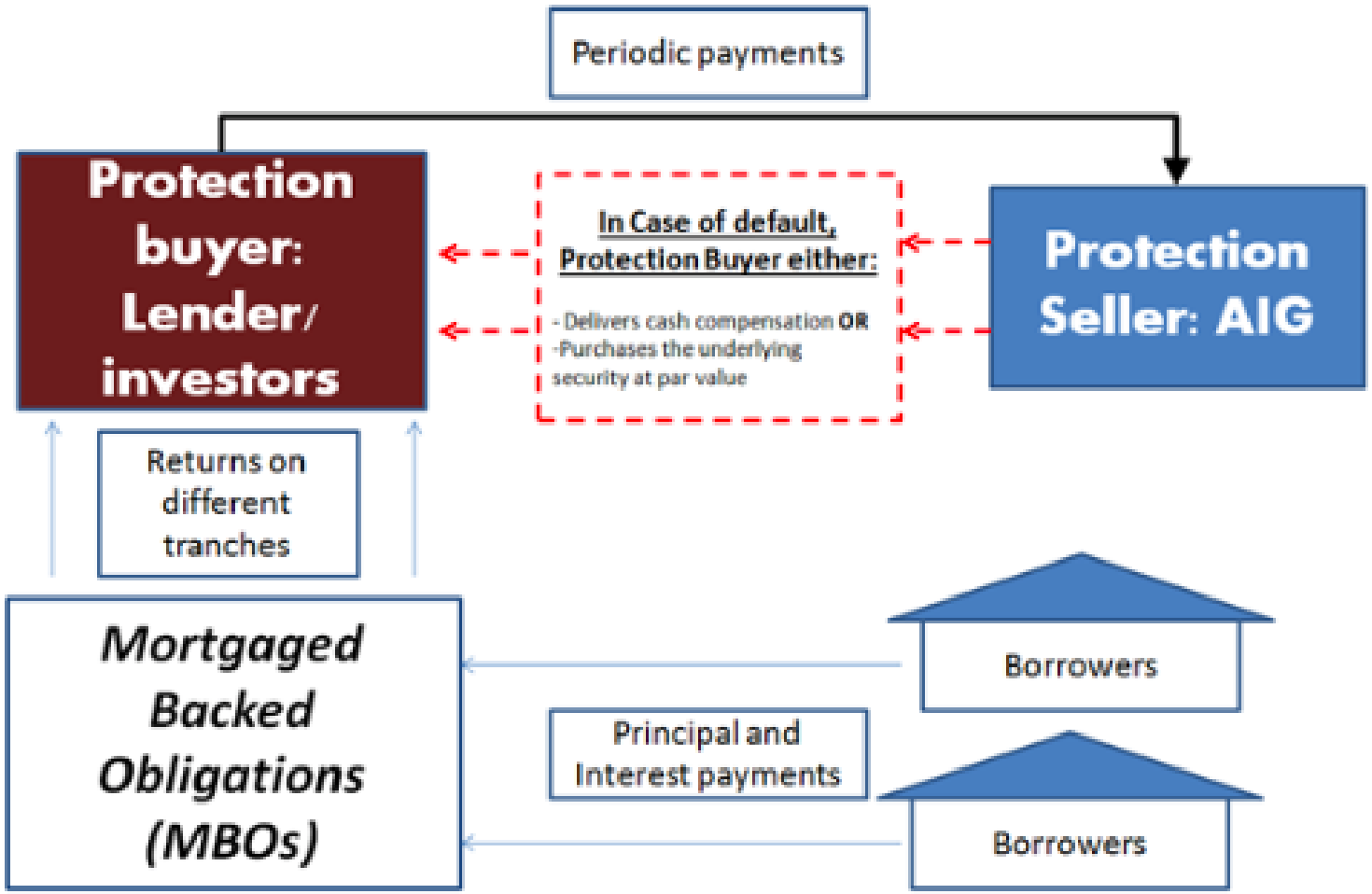
6) Why swaps? a) change the nature of cash flow; b) leverage strengths in different markets.

Case Study: How AIG Fell Apart? (w)

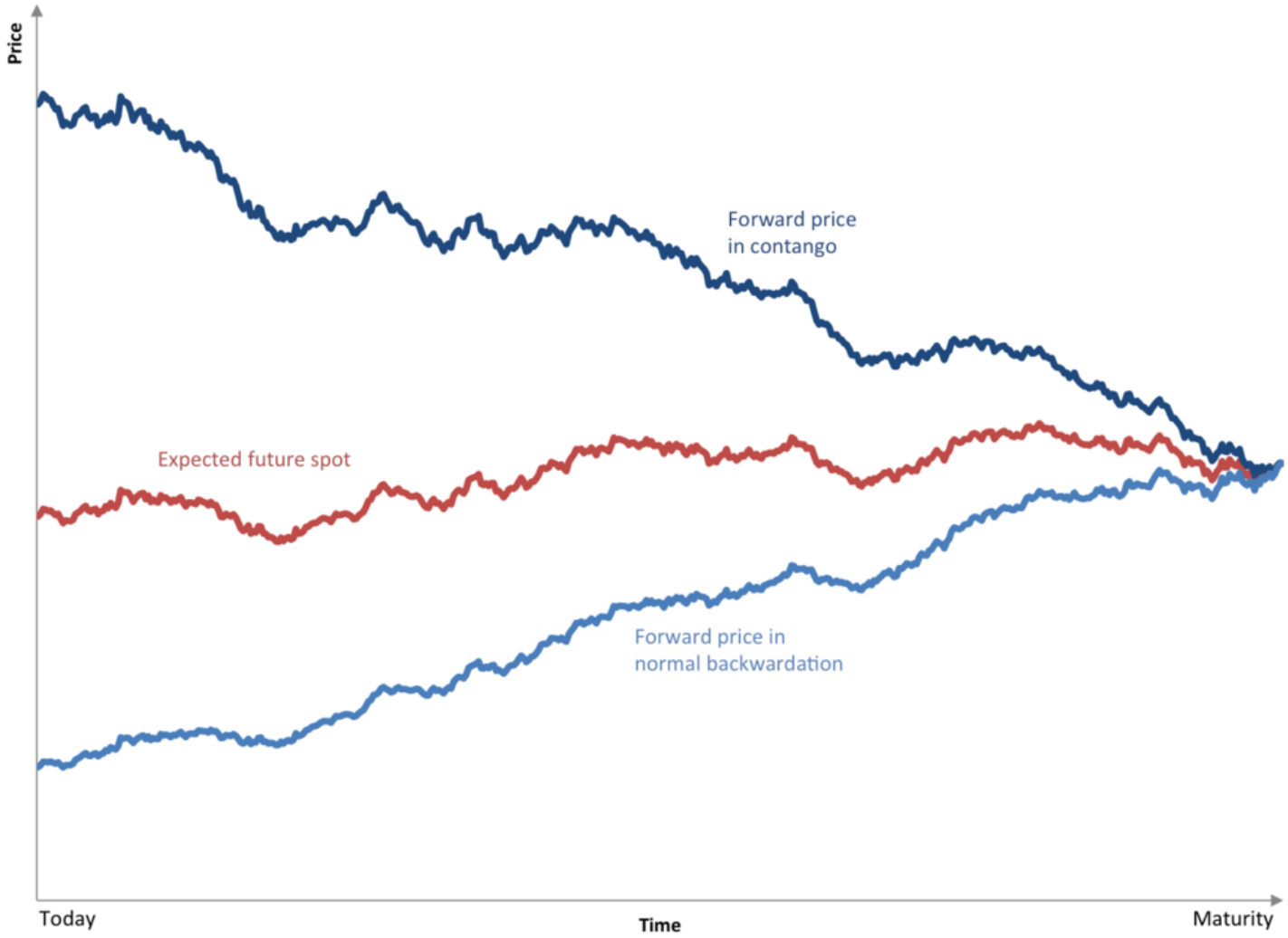
"As AIG Goes, So Goes The Global Economy?!"

- In 2008 when you heard that the collapse of AIG or Lehman Bros. or Bear Stearns might lead to a systemic collapse of the global financial system, the feared culprit is, largely, that instrument known as a credit default swap (CDS).
- Unlike traditional insurers, AIG was heavily involved in writing CDS. Before the financial crisis, AIG underwrote huge amounts of CDS (57.8Bn) on Mortgage-backed securities (MBS).
- Impacts of crisis on AIG: 1) liquidity crunch (insured more than 440Bn fixed income investments); 2) severely damaged reputation (180Bn US gov bailout). Suggested risk management solutions: 1) Greater degree of regulation over the OTC derivatives; 2) Standard for monitoring capital adequacy and risk exposure of insurers; 3) Proper assignment of credit ratings.

AIG's Involvement in MBS (w)



Appendix 1: Forward Price Convergence



Appendix 2: Financial Derivatives - "Deadly Weapons"

- In 1994, the Community Banker's U.S. Government Money Market Fund closed its doors due to derivatives- related losses, paying off its shareholders (mainly community banks) about 94 cents on the dollar.
- In 1995, Nicholas Leeson's estimated losses from trading futures contracts amounted to $1.4Bn and led to the collapse of Barings–Great Britain's 242-year-old merchant bank.
- In 2007-2009 period, investment banks, led by Lehman Brothers, collapsed as mortgage-backed securities plummeted in value. The contagion set in motion by the Lehman collapse led to dozens of failures of moderate-size commercial banks.

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[2] Wiki Website for Forwards, Futures and Swaps. (1) (2) (3)

[3] Bank for International Settlements (BIS) Derivatives Statistics (w)

[4] International Swaps and Derivatives Association (ISDA), Inc. (w)

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