Michael Bloss | Dietmar Ernst | Joachim Häcker

Derivatives

An authorative guide to derivatives for financial intermediaries and investors

Author

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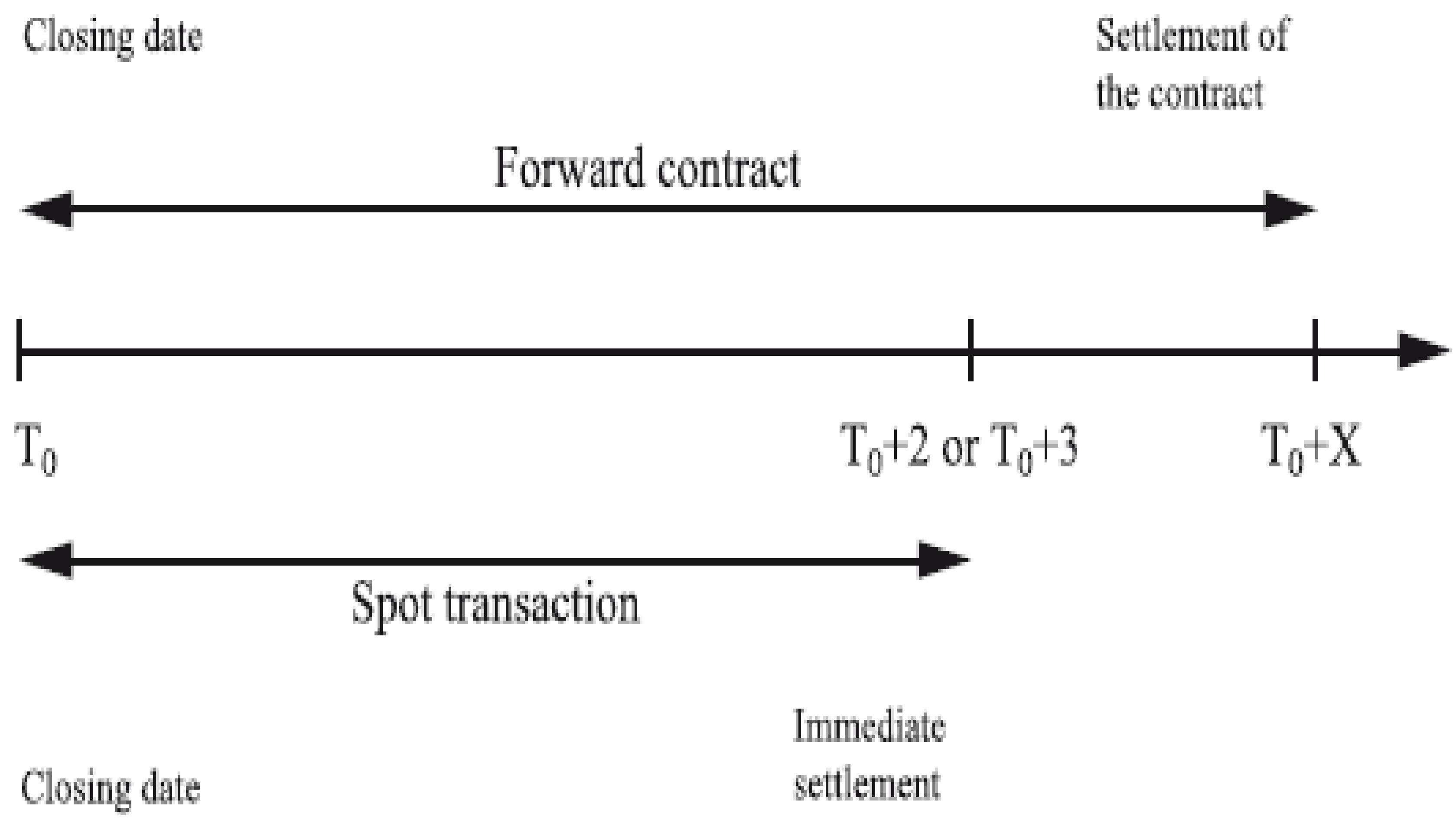
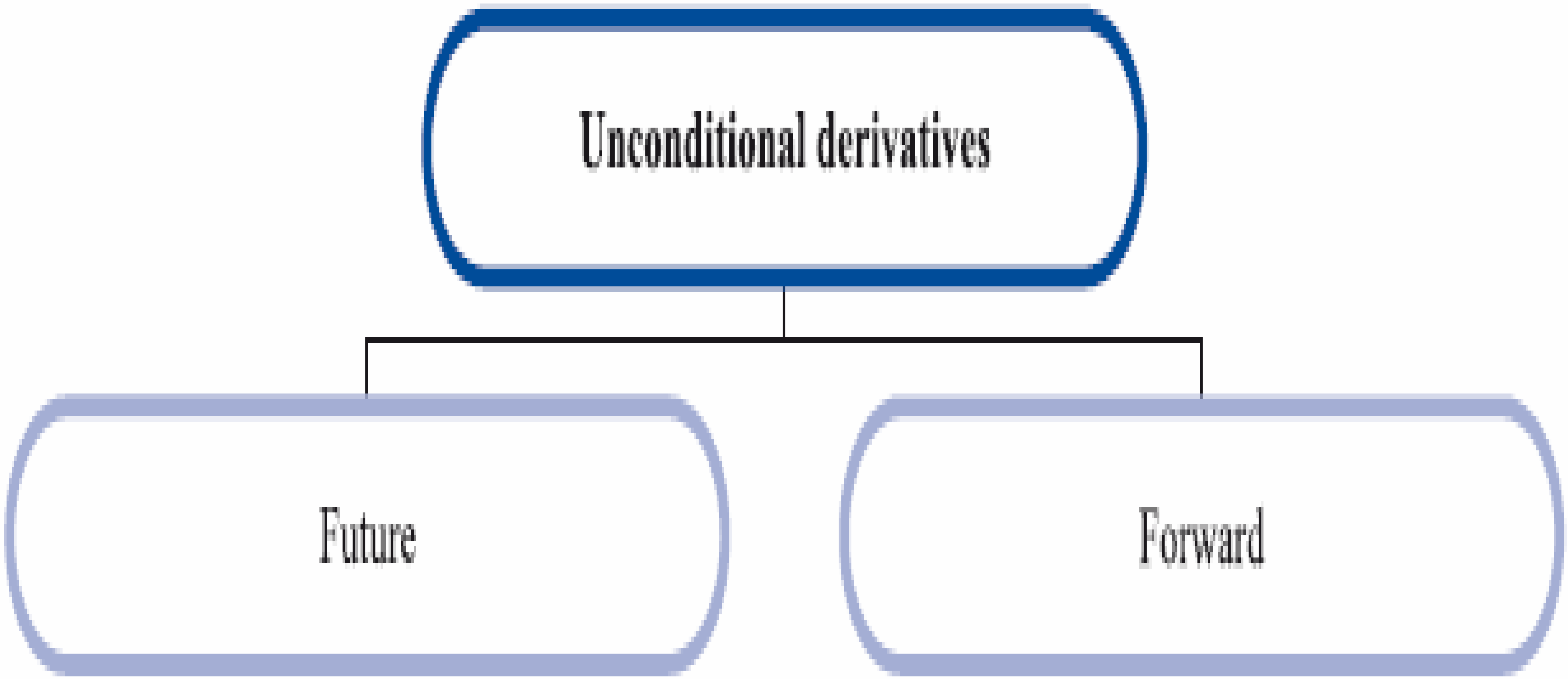
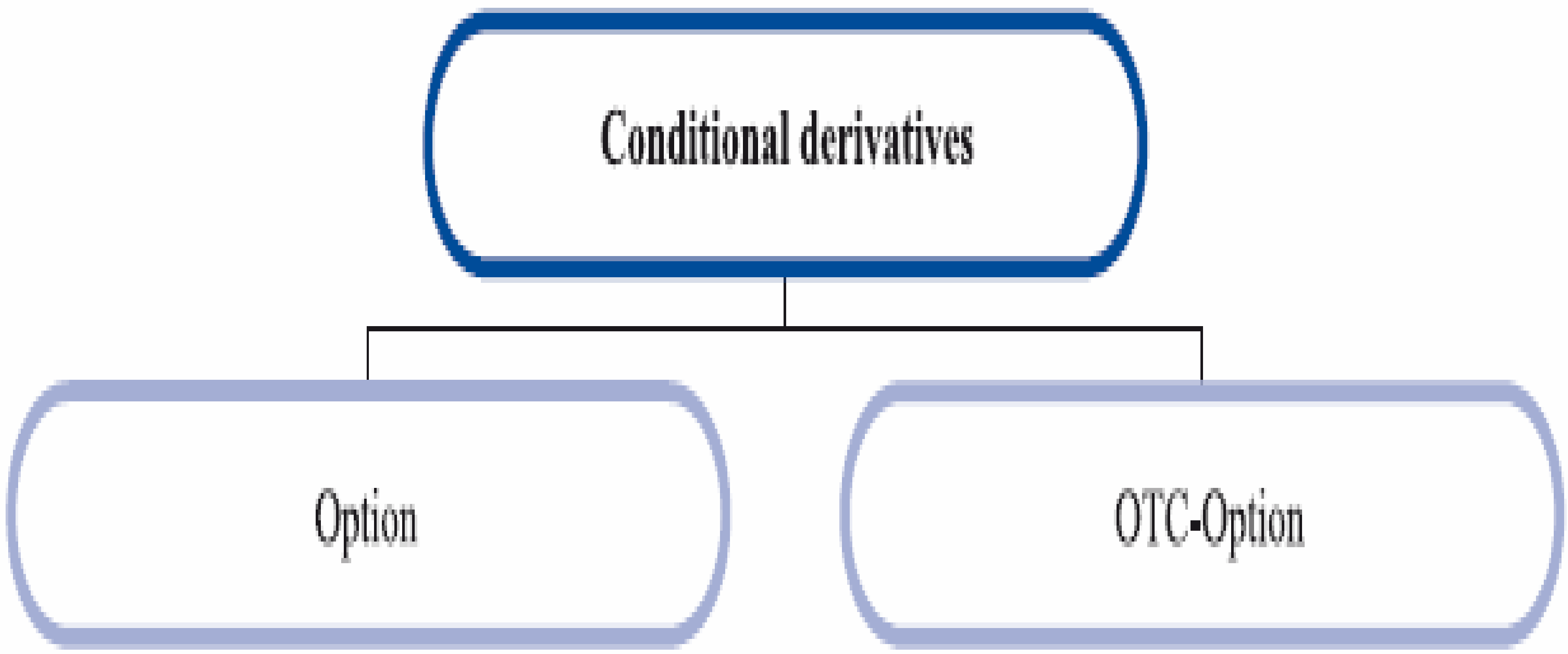
Point of fulfilment



Unconditional derivatives



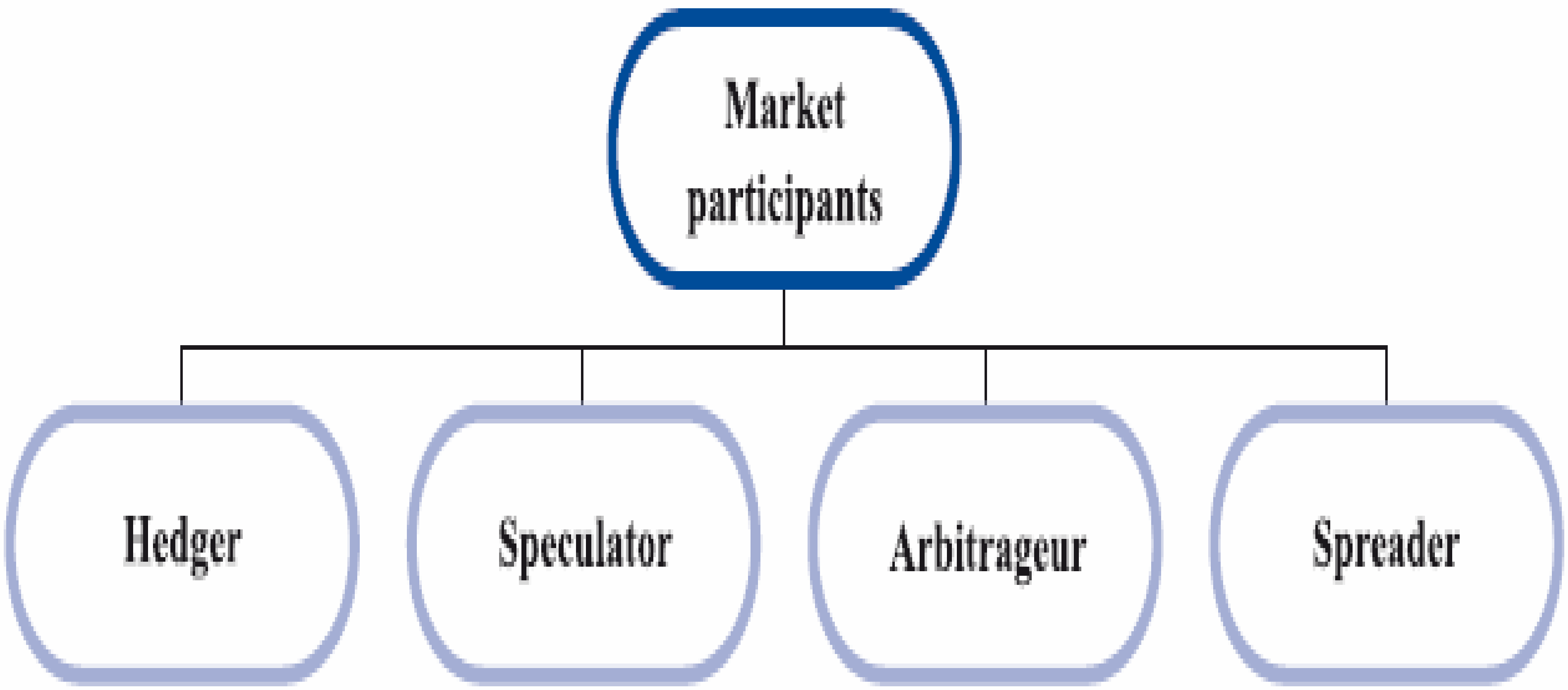
Conditional derivatives



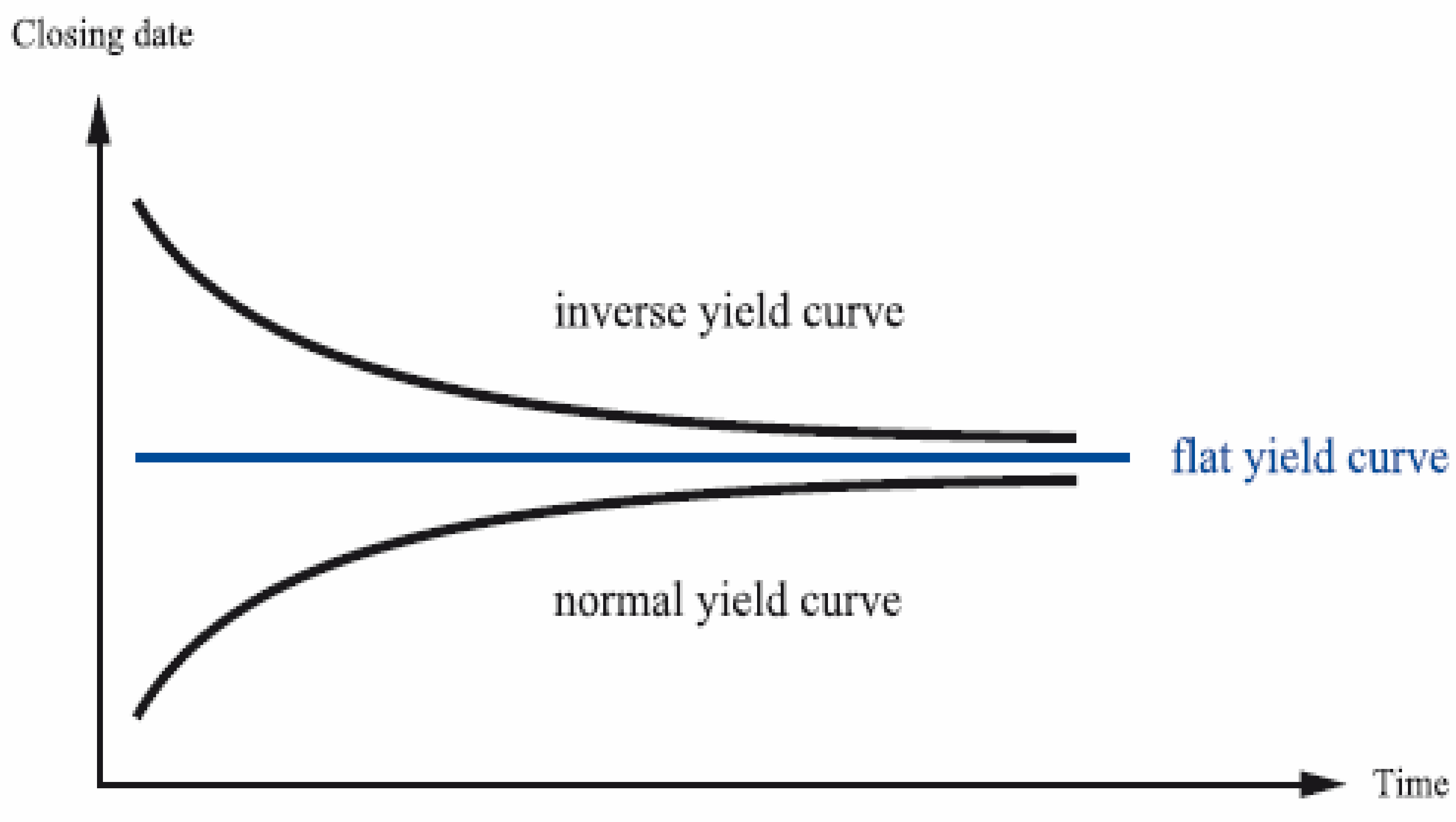
Opening vs. Closing

Opening (Initial order)	**Closing (counter-order)**
Long	Short
Short	Long

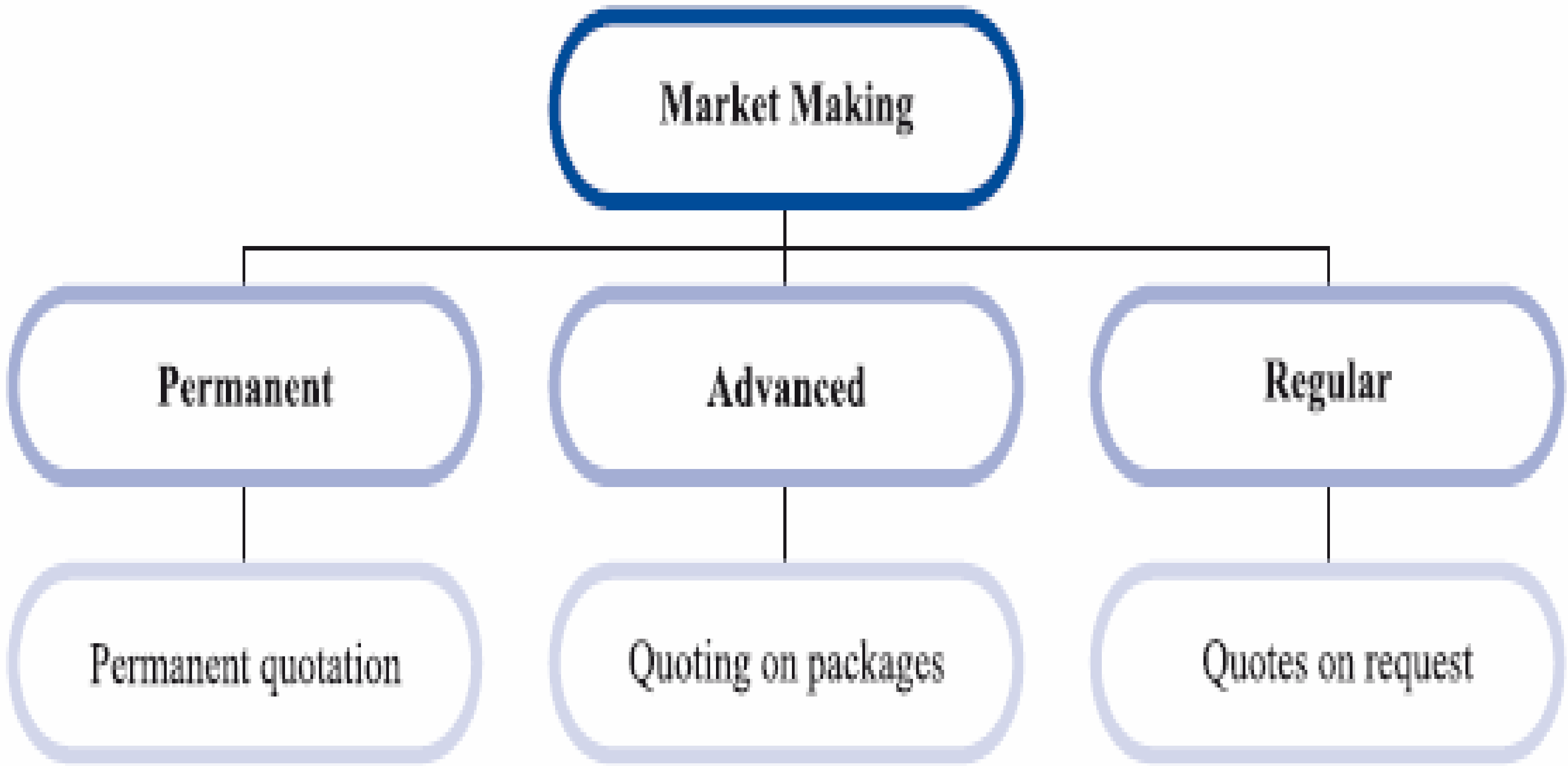
Market participants



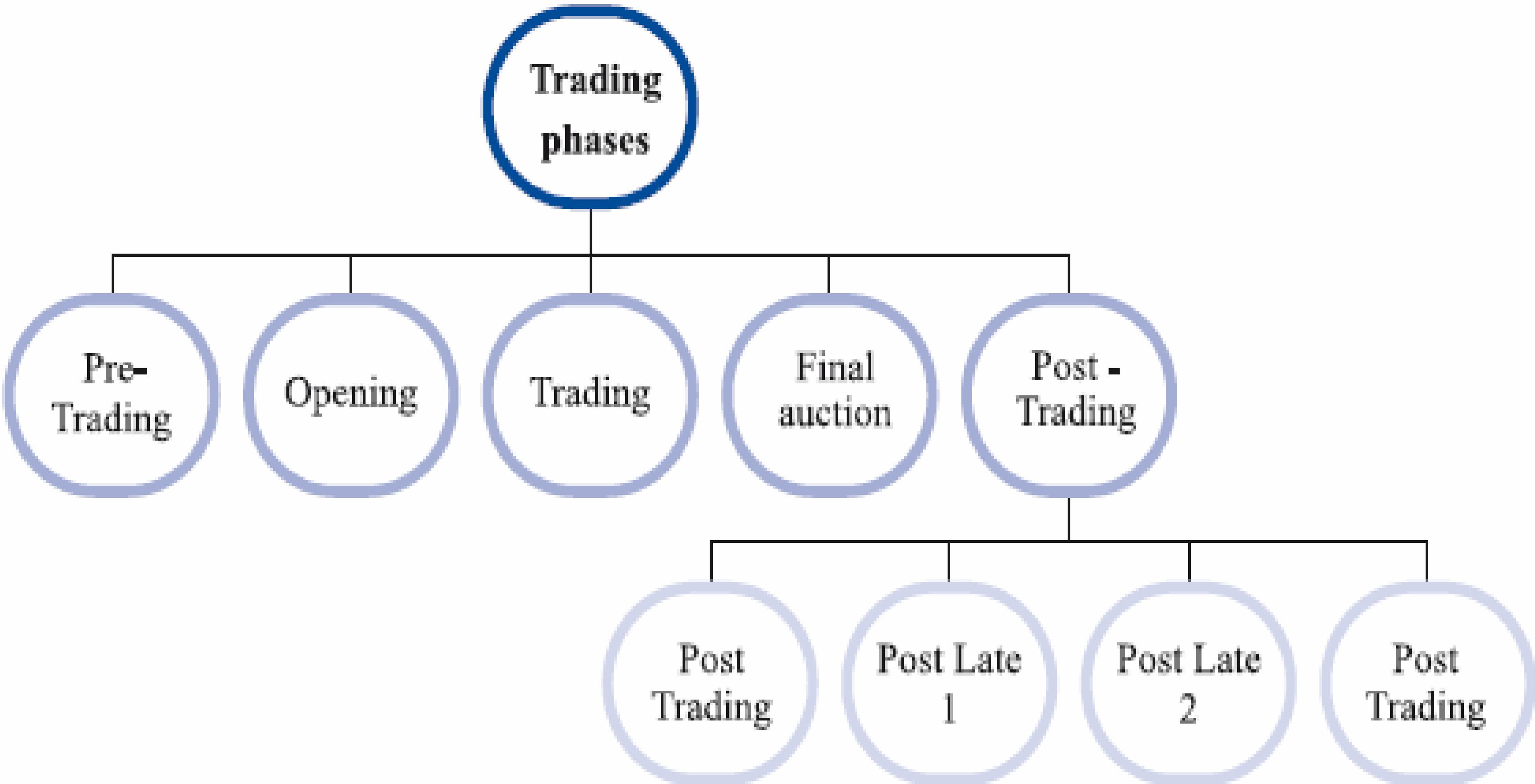
Interest structure curves



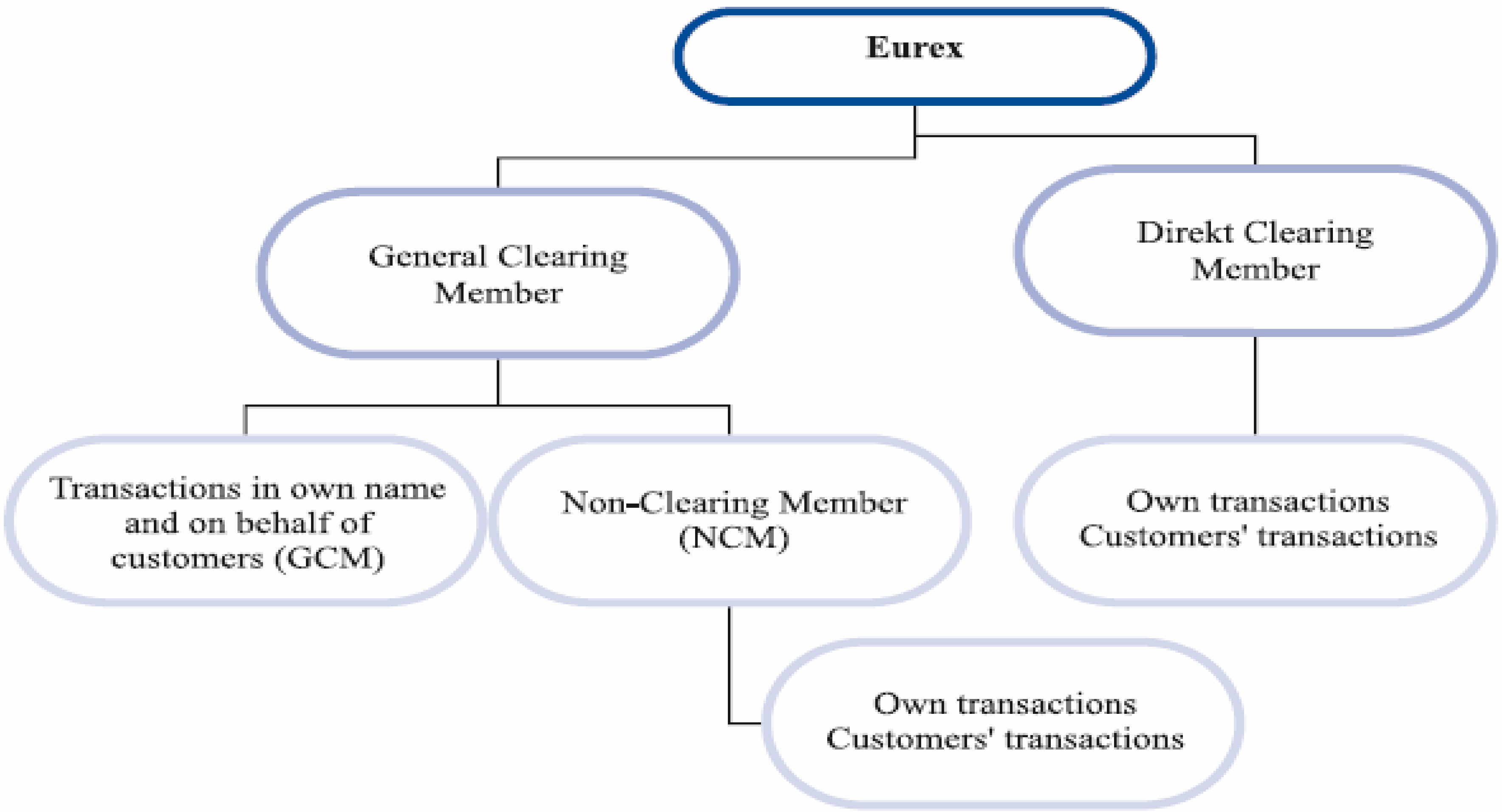
Market Making



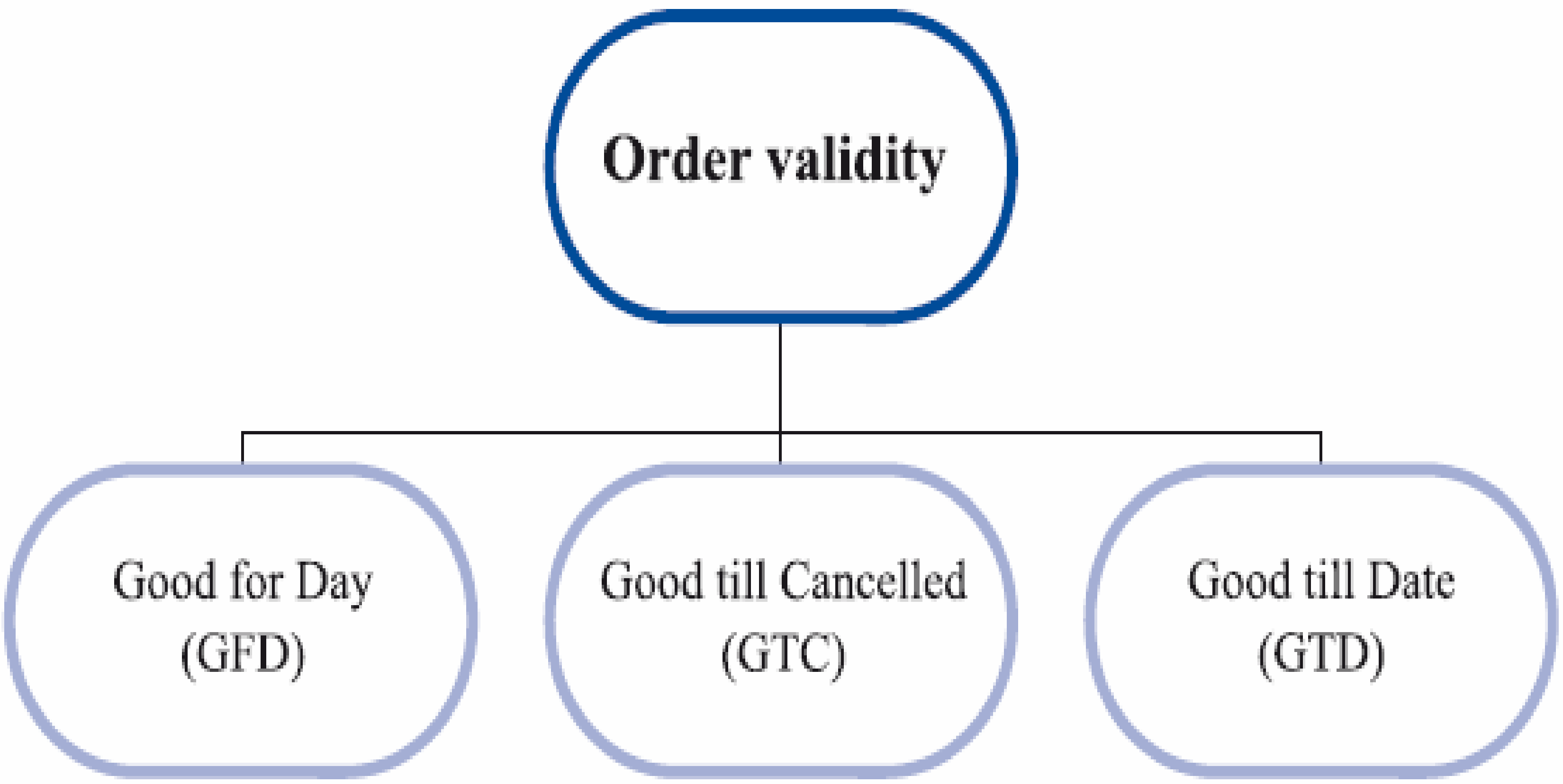
Eurex trading phases



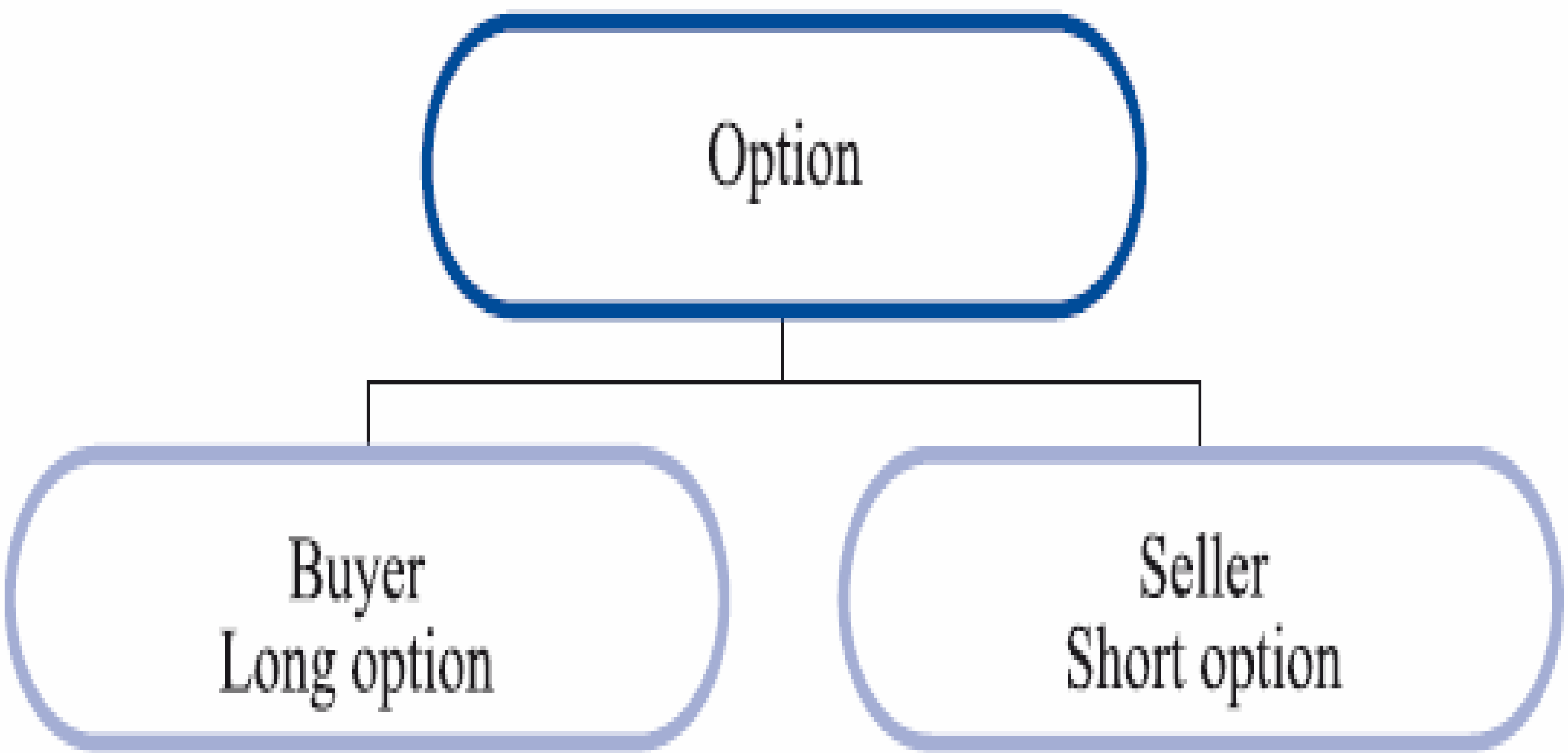
Eurex Clearing



Order validity



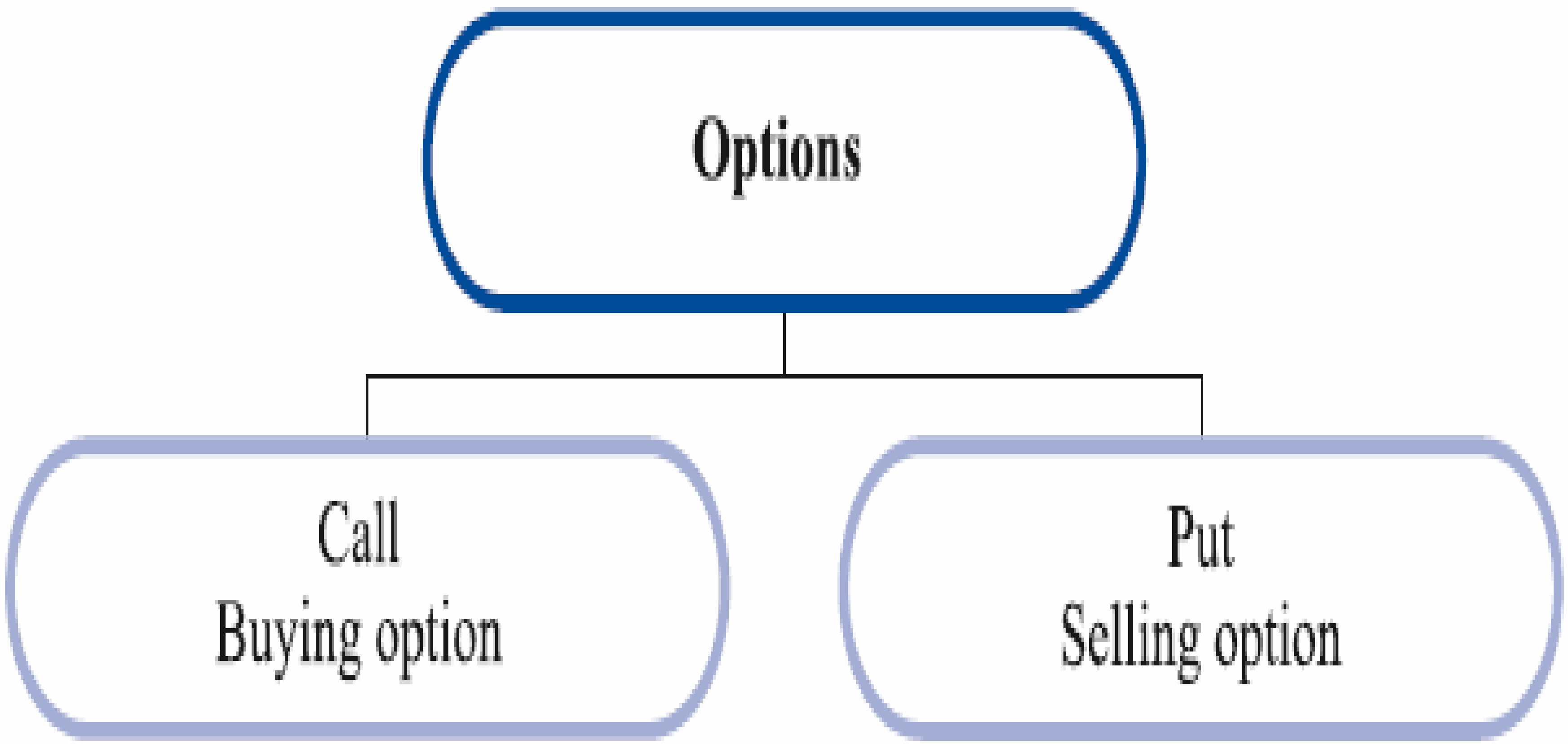
Options



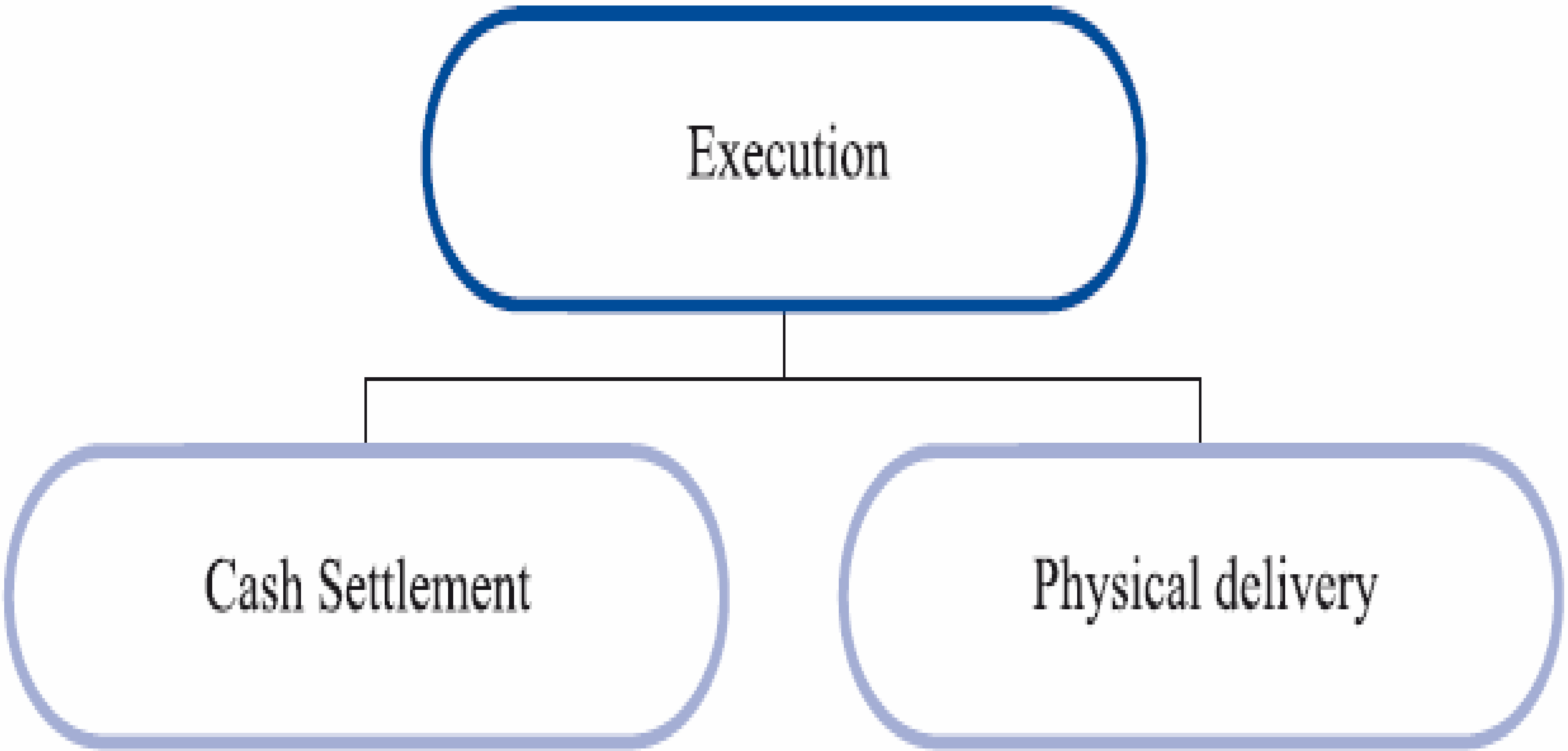
Right and Obligation

	Right	Obligation
Buyer	Exercise of option	Payment of premium
Seller	Receiving premium	Delivery or receipt

Call and Put



Execution of an option



Opening vs. Closing

Opening	Close-out
Long call	Short call
Short call	Long call
Long put	Short put
Short put	Long put

Pricing of a option

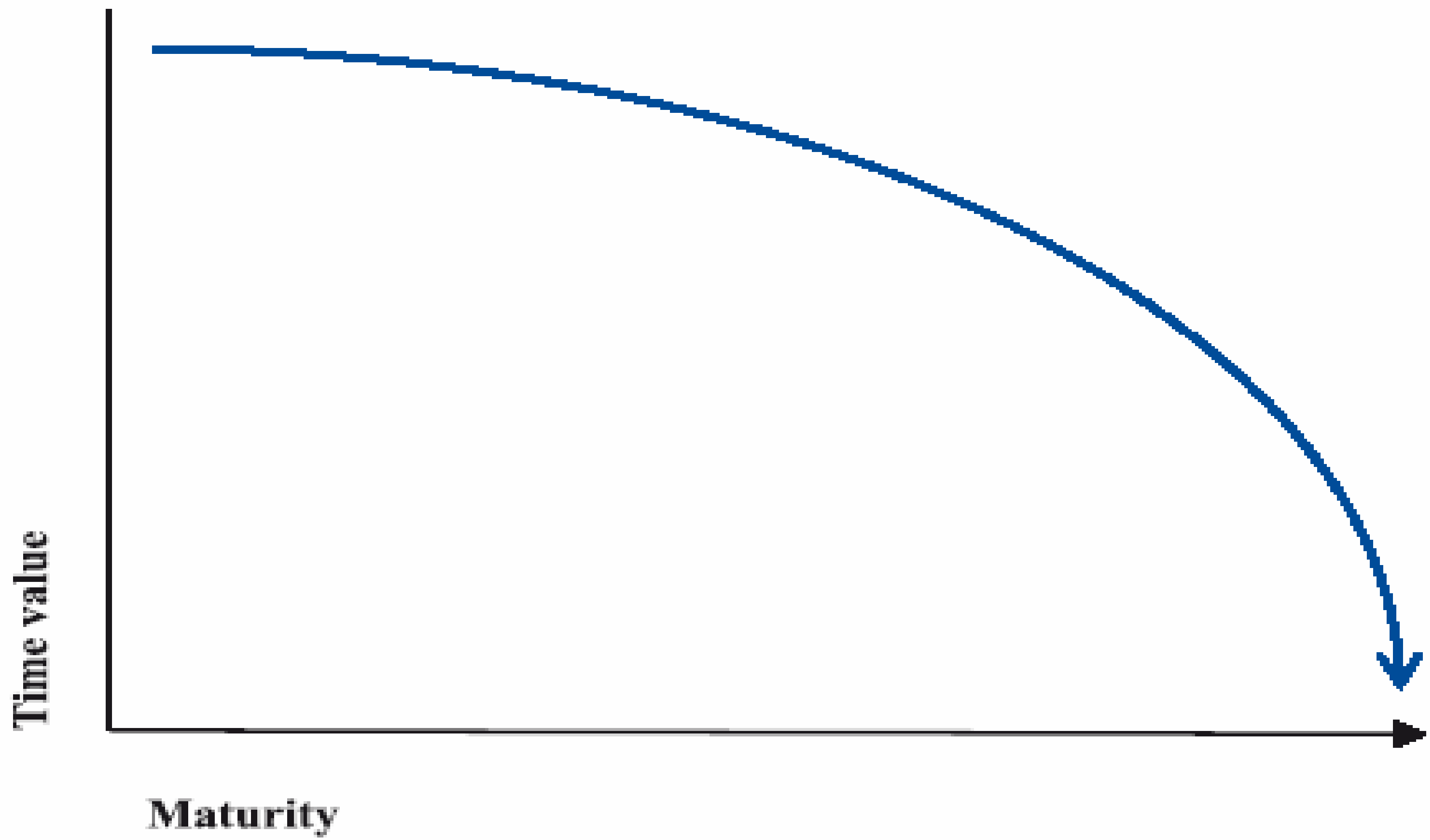
A call option has an intrinsic value if the price of the underlying is higher than the strike price of the option.

A put option has an intrinsic value if the price of the underlying is lower than the strike price of the option.

	In the money	At the money	Out of the money
Call	Price of underlying > strike price	Price of underlying = strike price	Price of underlying < strike price
Put	Price of underlying < strike price	Price of underlying = strike price	Price of underlying > strike price

The intrinsic value can be equal to zero, but can never be negative.

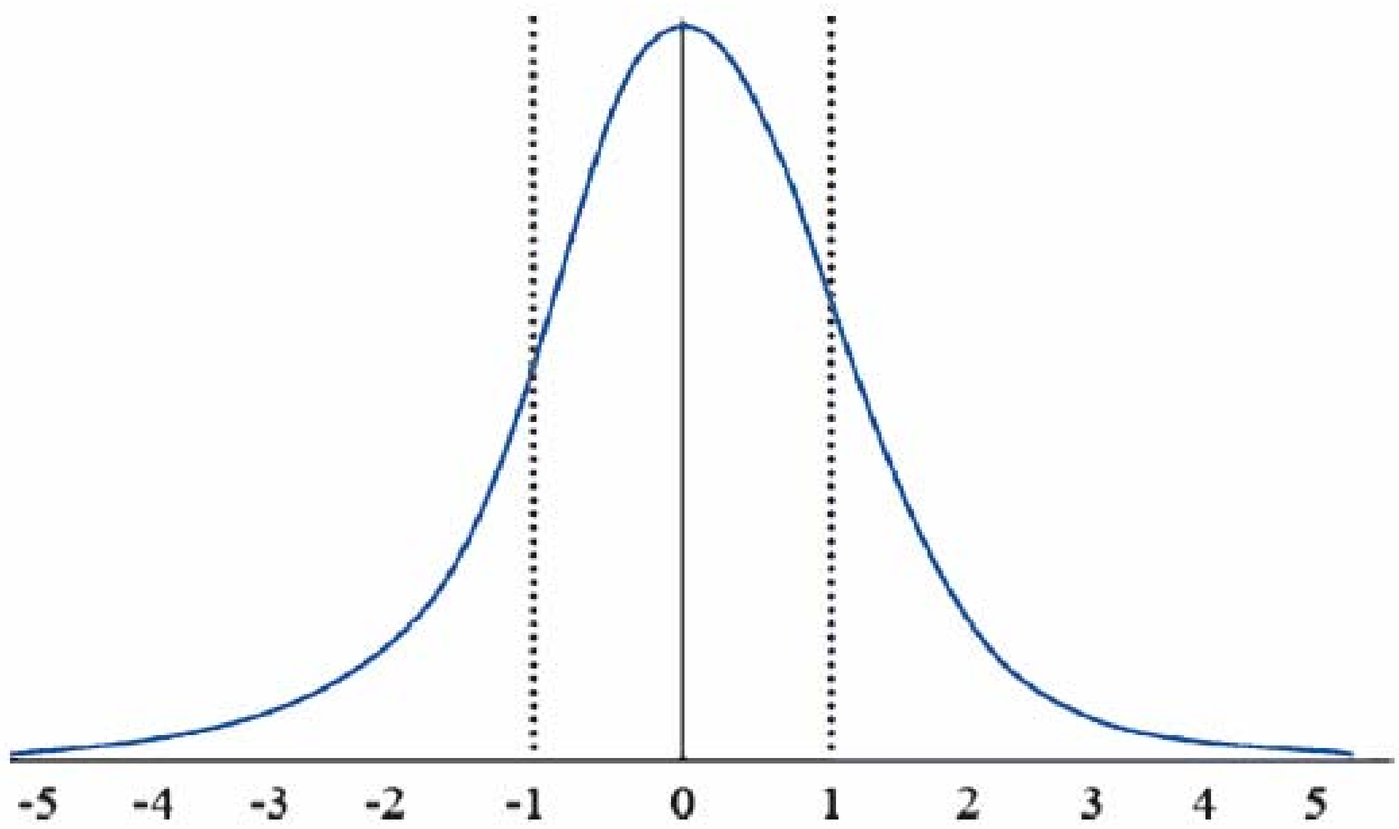
Time value



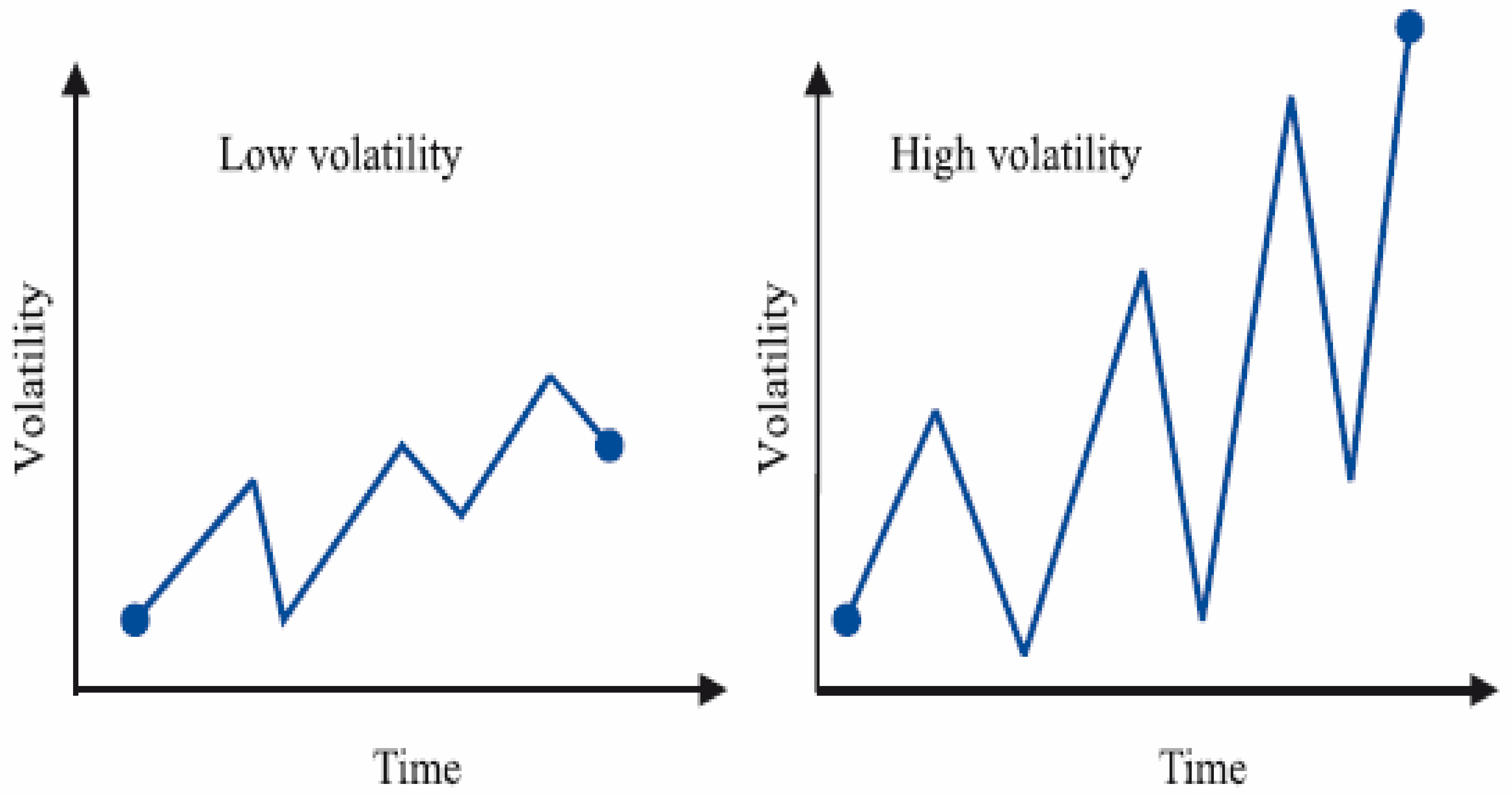
Time value

Options with a short remaining term should be sold because their time value is rapidly decreasing, and options with a long remaining term should be purchased.

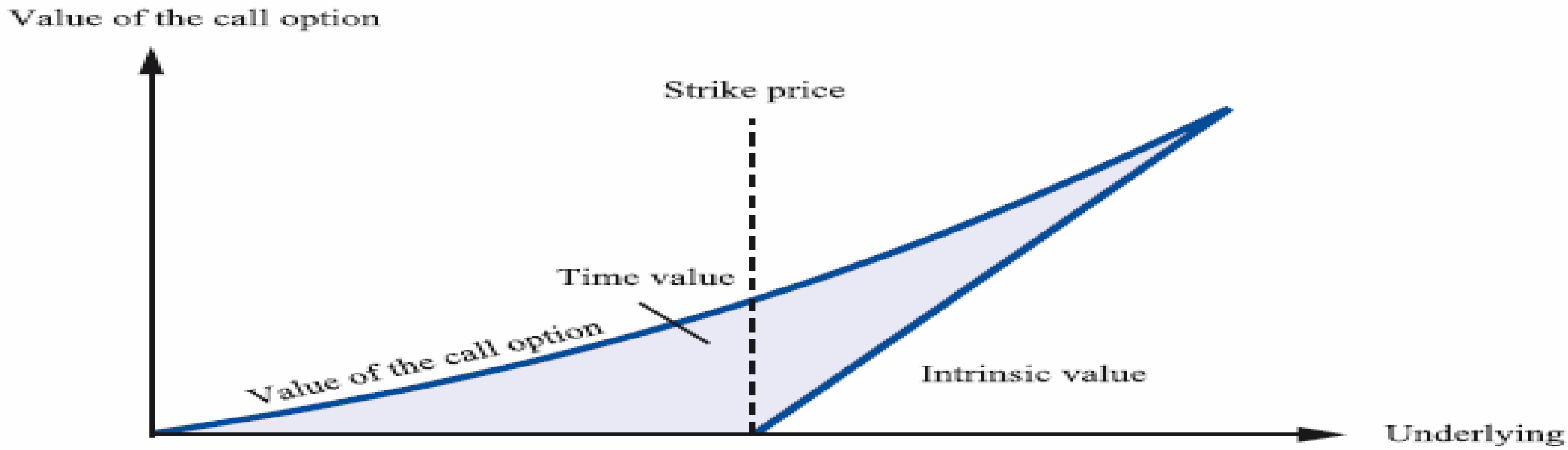
Gaussian bell curve

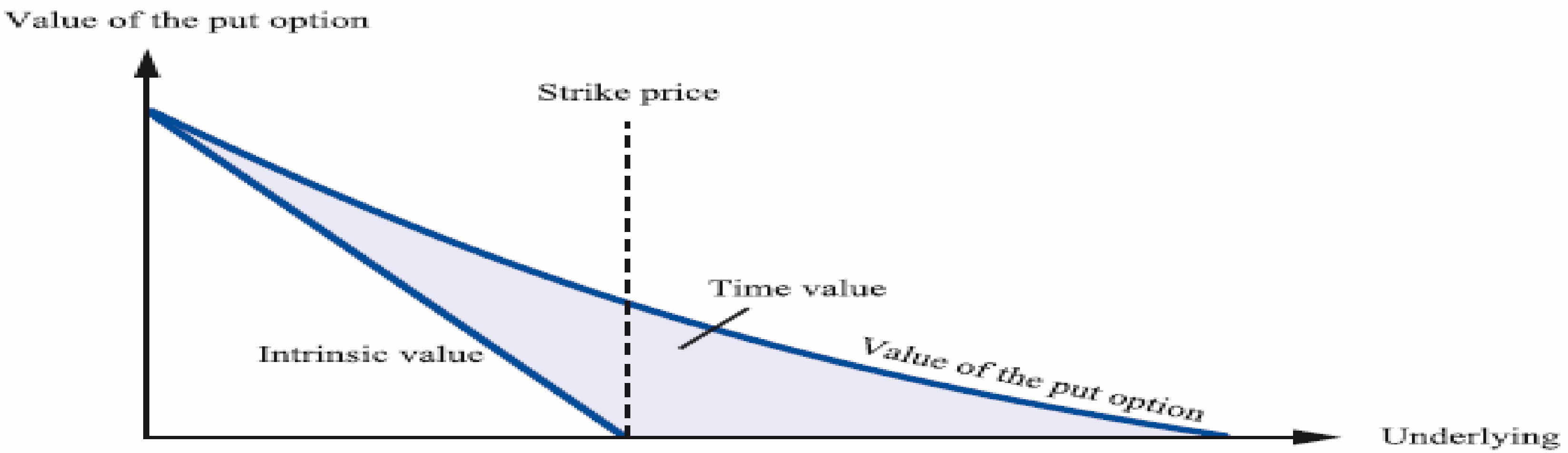


Volatility


Low volatility
Volatility
Time
High volatility
Volatility
Time

Time value


Value of the call option
Strike price
Time value
Value of the call option
Intrinsic value
Underlying

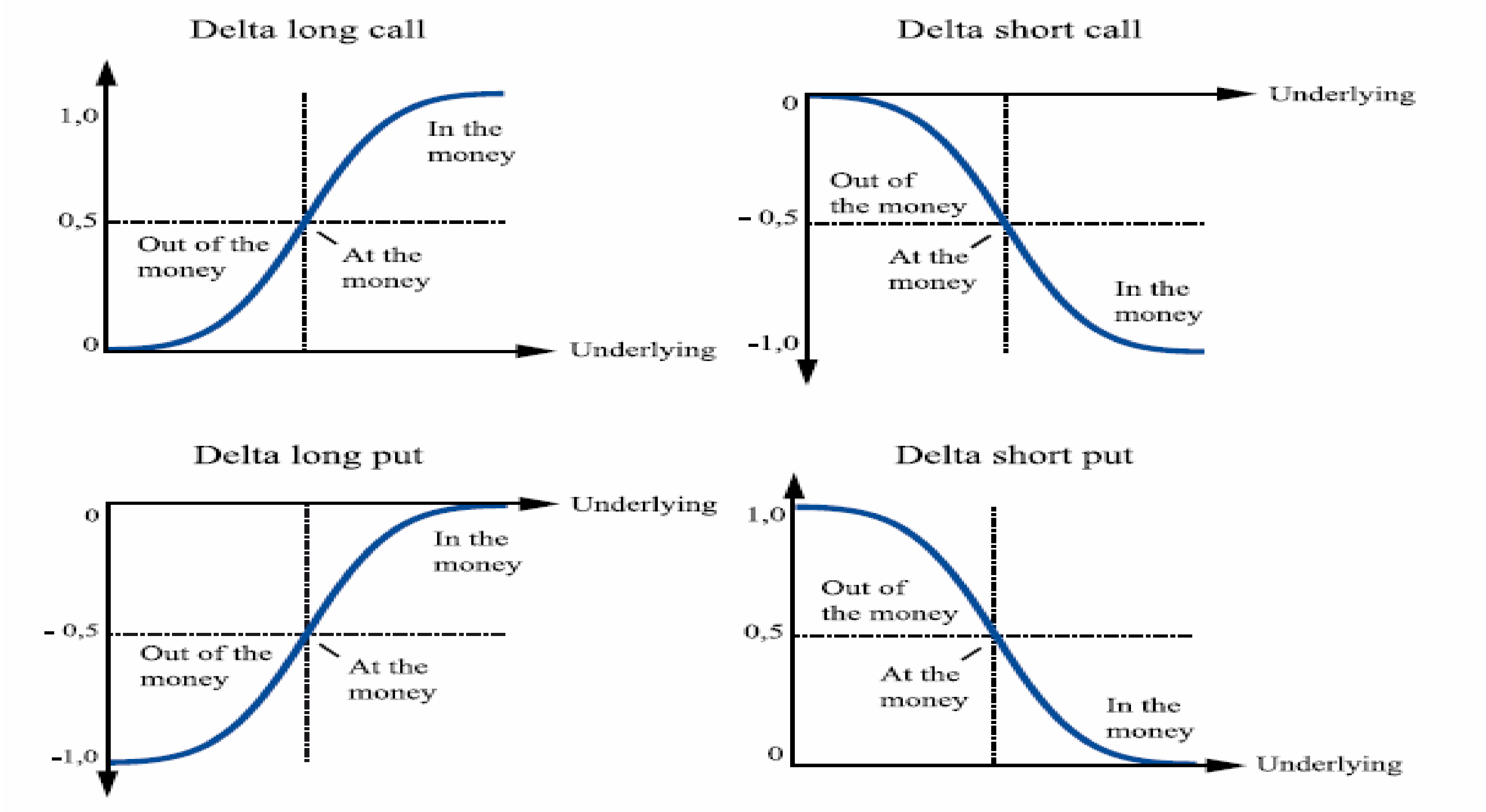

Value of the put option
Strike price
Time value
Intrinsic value
Value of the put option
Underlying

Parameters

Parameter		Option price Call	Option price Put
Underlying	increases	increases	decreases
	decreases	decreases	increases
Volatility	increases	increases	increases
	decreases	decreases	decreases

Parameter		Option price Call	Option price Put
Remaining maturity	decreases	decreases	decreases
Market interest rate	increases	increases	decreases
	decreases	decreases	increases
Dividend payout American-style		decreases	increases
European-style		remains unchanged	remains unchanged

Delta

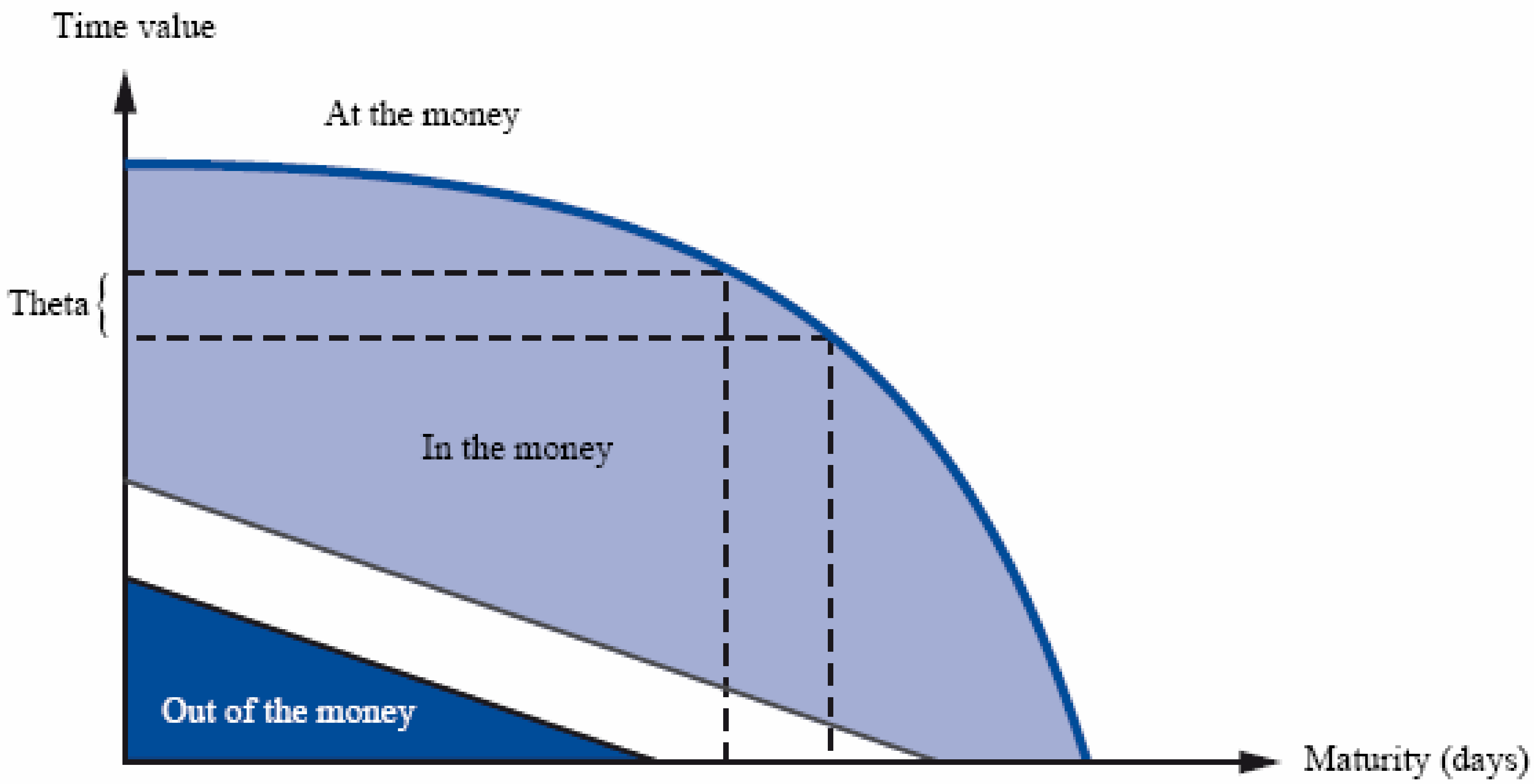

Delta long call
1,0
0,5
0
Out of the money
At the money
In the money
Underlying
Delta short call
0
- 0,5
-1,0
Out of the money
At the money
In the money
Underlying
Delta long put
0
- 0,5
-1,0
Out of the money
At the money
In the money
Underlying
Delta short put
1,0
0,5
0
Out of the money
At the money
In the money
Underlying

Delta

	Long	Short
Call	+	–
Put	–	+

Delta of a…	Out of the money	At the money	In the money
Long call / short put	Approx. 0 to 0.5	Approx. 0.5	Approx. 0.5 to 1
Long put / short call	Approx. 0 to –0.5	Approx. –0.5	Approx. 0.5 to –1

Theta



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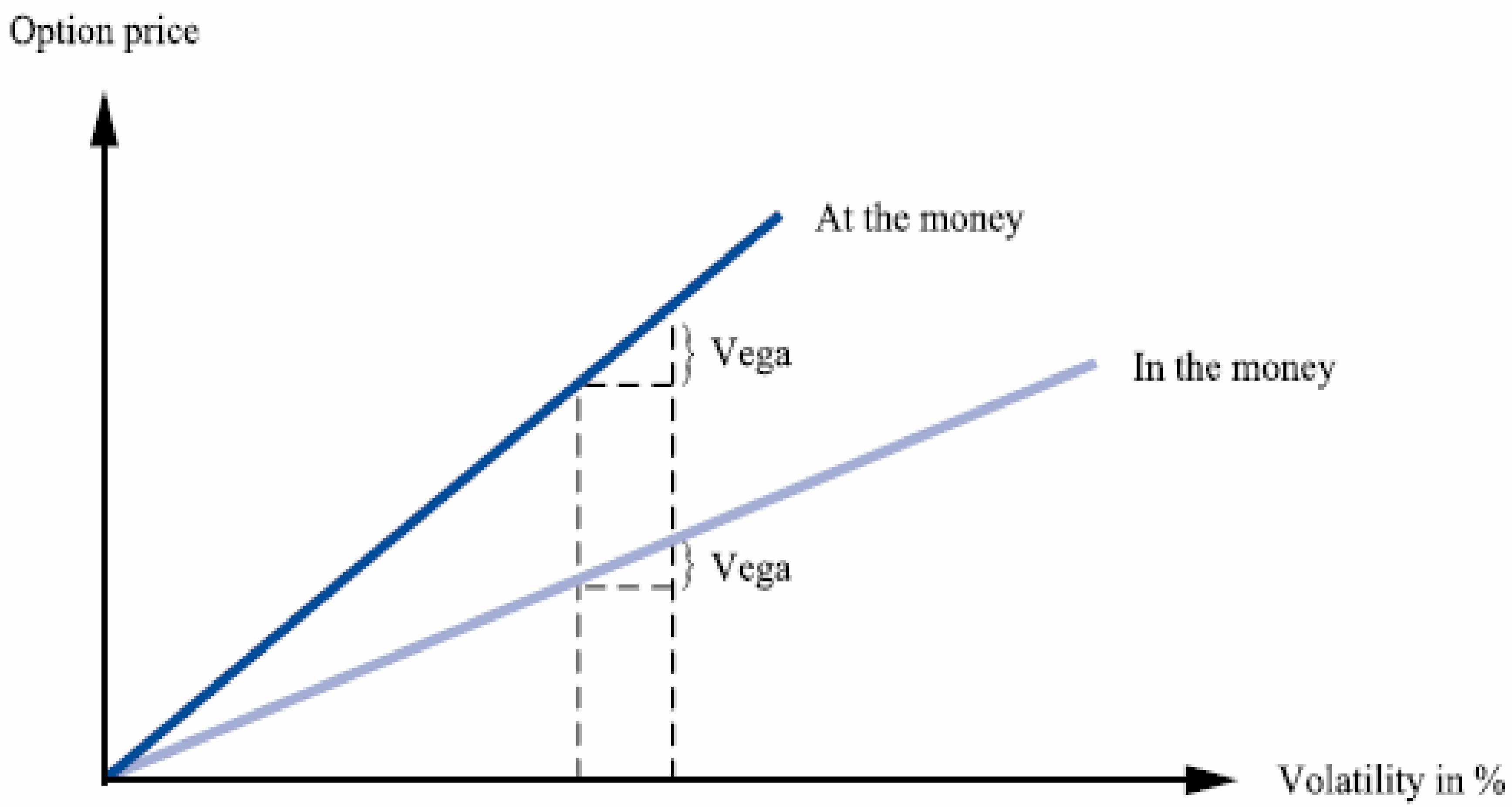
Vega


Option price
At the money
Vega
In the money
Vega
Volatility in %

Overview of algebraic signs for Greeks

	Delta	Gamma	Vega	Theta	Rho
Long call	positive	positive	positive	negative	positive
Short call	negative	negative	negative	positive	negative
Long put	negative	positive	positive	negative	negative
Short put	positive	negative	negative	positive	positive

Put Call Parity

$$C = (S - E) + \left(E \times \left(\frac{r}{1 + r}\right)\right) + V$$

Where:

C = call price

$S - E$ = intrinsic value

$(E \times (r/(1 + r))$ = opportunity cost of the writer

V = insurance premium

E = strike price

$$C = S - E \times \frac{1}{(1 + r)^t} + P$$

Where:

t = annualized remaining maturity

P = put price

Black-Scholes option pricing model

$$c = S_0 N(d_1) - K e^{-rT} N(d_2)$$

$$p = K e^{-rT} N(-d_2) - S_0 N(-d_1)$$

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

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

$$\frac{\partial V}{\partial t} + \mathrm{rS}\frac{\partial V}{\partial S} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} = rV$$

Where:
S_0 = price of the underlying share
K = strike price of the call option
ln = natural logarithm
e = basis of natural logarithm = 2.7128
r = risk-free interest rate
$N(d)$ = cumulative normal distribution of d
v = volatility
t = remaining maturity of call

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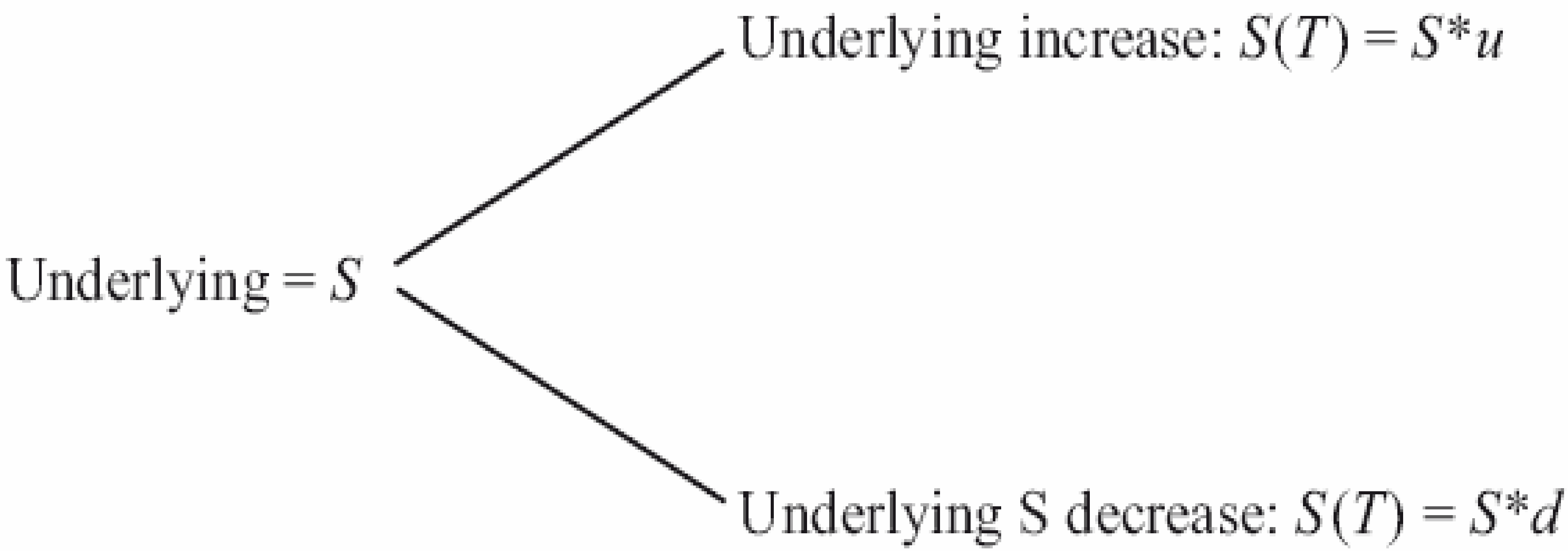
Cox, Ross & Rubinstein



Where:

S = price of the underlying share

u = rate of increase

d = rate of decrease

Cox, Ross & Rubinstein

Option price: C
riskless Portfolio $S^*\Delta - C$

Underlying increase: $S(T) = S^*u$
Option price: C_u
riskless Portfolio: $S^*u^*\Delta - C_u$

Underlying S decrease: $S(T) = S^*d$
Option price: C_d
riskless Portfolio: $S^*d^*\Delta - C_d$

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Cox, Ross & Rubinstein

$$S \cdot u \cdot \Delta - C_u = S \cdot d \cdot \Delta - C_d \Leftrightarrow$$

$$\Delta = \frac{C_u - C_d}{S \cdot u - S \cdot d}$$

$$(S \cdot u \cdot \Delta - C_u)e^{-rT} \; with \; \Delta = \frac{C_u \quad C_d}{S \cdot u - S \cdot d} \rightarrow$$

$$S \cdot \Delta - C = (S \cdot u \cdot \Delta - C_u)e^{-rT} \rightarrow$$

Call at time $0 =$

$$C = S \cdot \Delta - (S \cdot u \cdot \Delta - C_u)e^{-rT} = S \cdot \frac{C_u - C_d}{S \cdot u - S \cdot d} - (S \cdot u \cdot \frac{C_u - C_d}{S \cdot u - S \cdot d} - C_u)e^{-rT}$$

Cox, Ross & Rubinstein

$$C = S \cdot \frac{C_u - C_d}{S \cdot u - S \cdot d} - (S \cdot u \cdot \frac{C_u - C_d}{S \cdot u - S \cdot d} - C_u)e^{-rT}$$

$$= \frac{pCu - (1-p)C_d}{e^{rT}} \qquad with \qquad p = \frac{e^{rT} - d}{u - d}$$

$$C = \frac{pC_u - (1-p)C_d}{e^{rT}} = \frac{E^P[C(T)]}{e^{rT}} \qquad with \qquad p = \frac{e^{rT} - d}{u - d}$$

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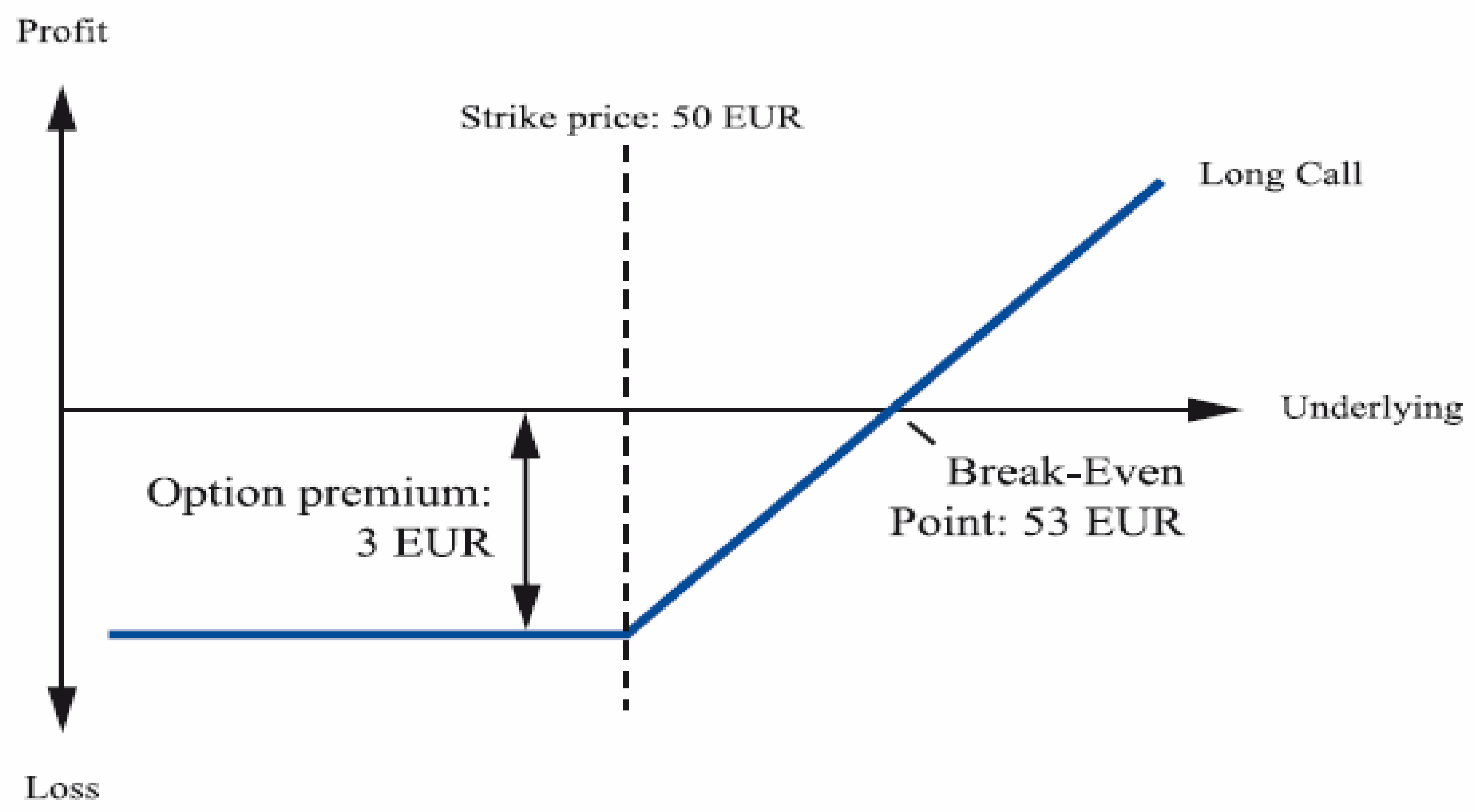
Cox, Ross & Rubinstein

$$E[S_T] = p \cdot S \cdot u + (1-p) \cdot S \cdot d \qquad with \qquad p = \frac{e^{rT} - d}{u - d} \leftrightarrow$$

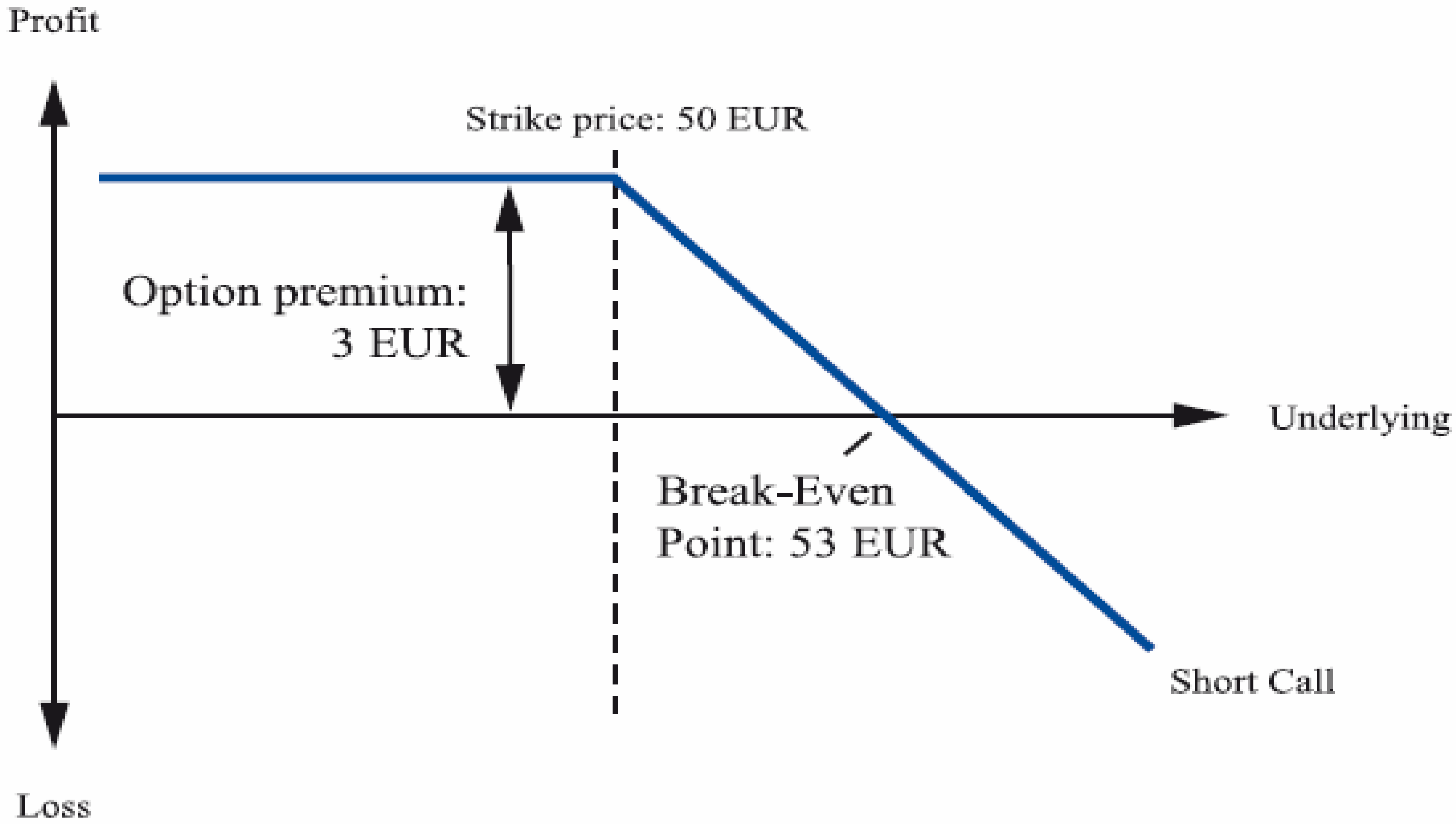
$$E[S_T] = p \cdot S \cdot (u-d) + S \cdot d = \frac{e^{rT} - d}{u - d} S \cdot (u-d) + S \cdot d$$

$$= e^{rT} \cdot S - d \cdot S + S \cdot d = Se^{rT}$$

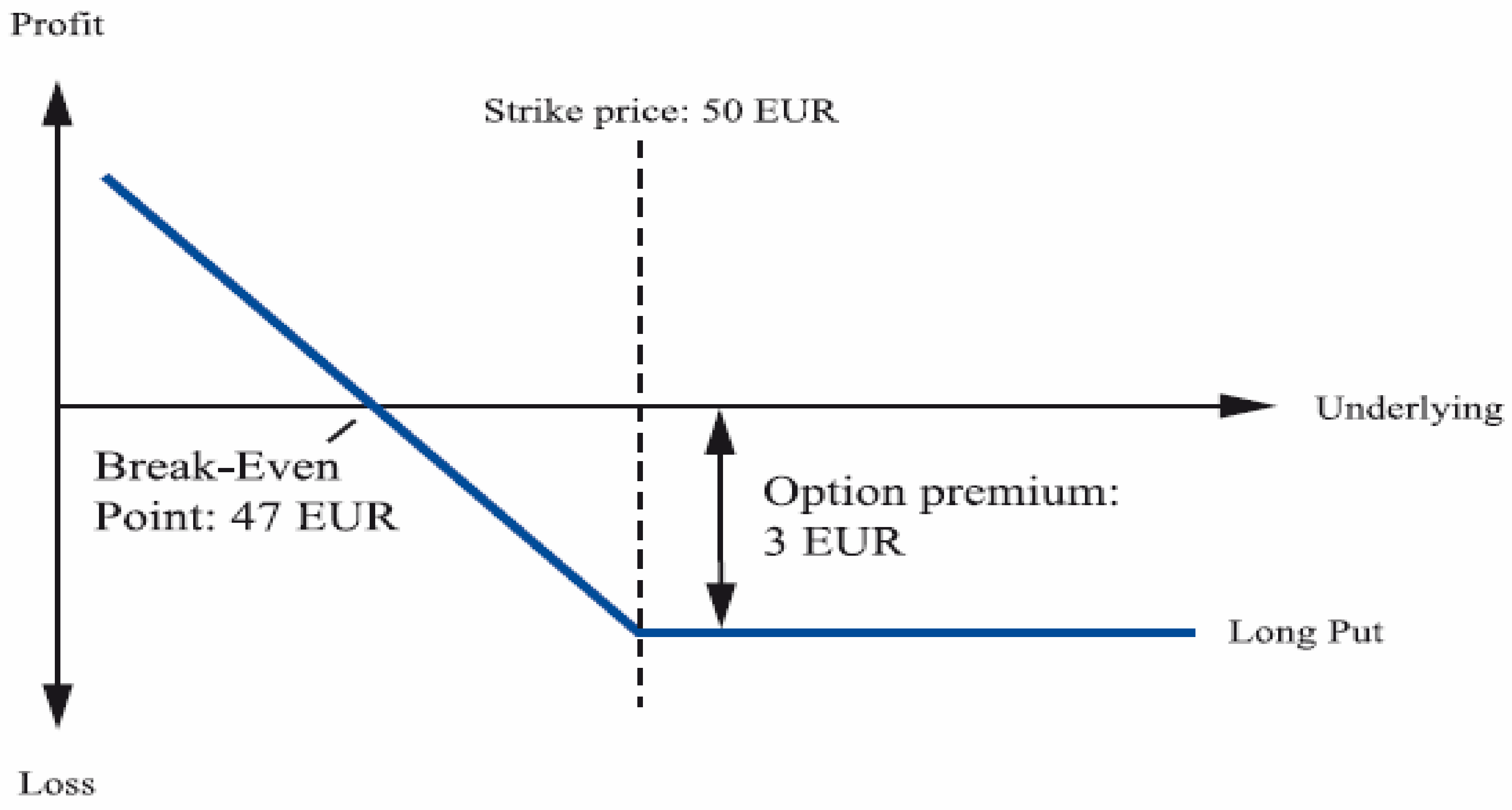
Long Call


Profit
Strike price: 50 EUR
Long Call
Underlying
Option premium:
3 EUR
Break-Even
Point: 53 EUR
Loss

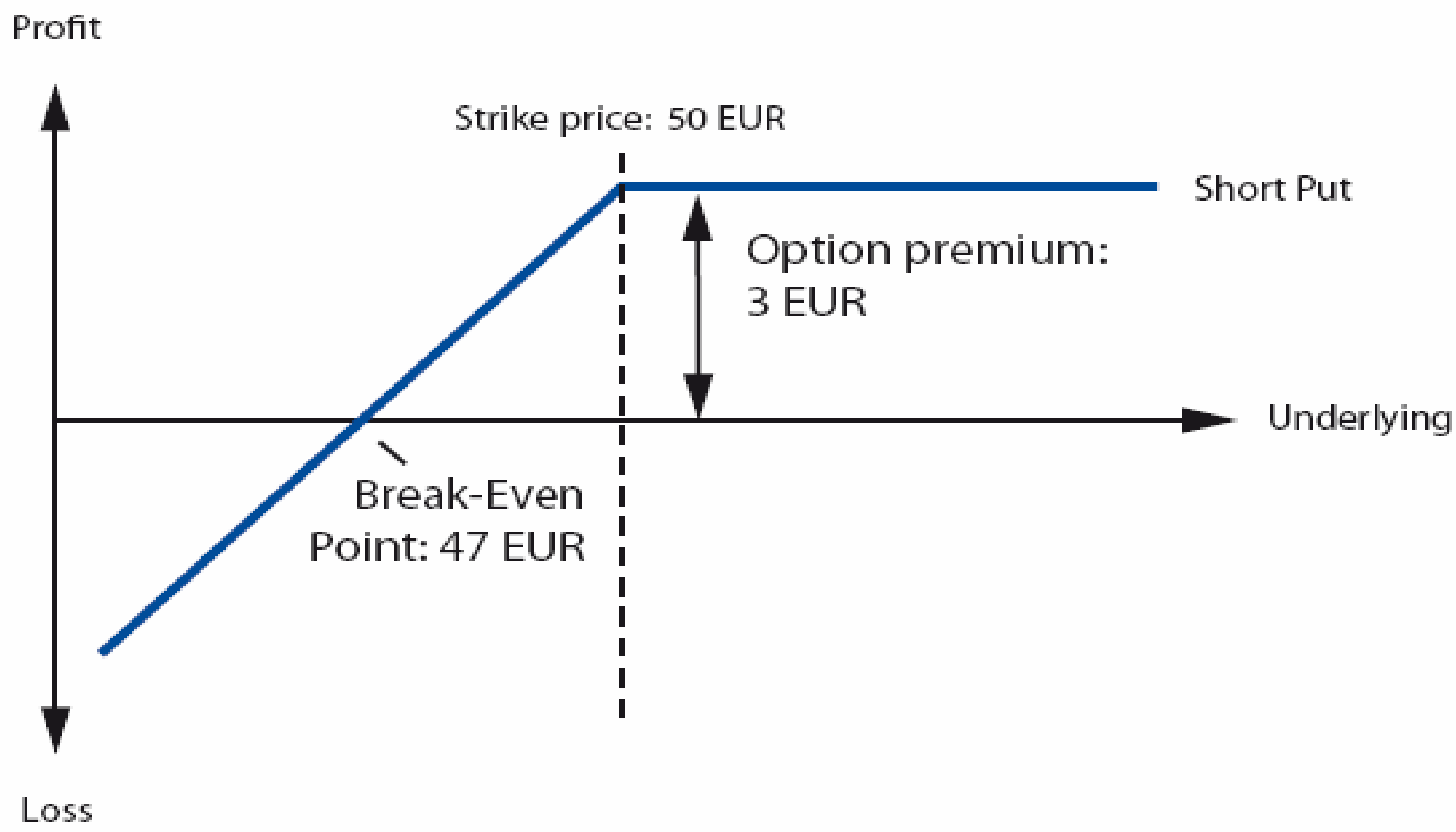
Short Call


Profit
Strike price: 50 EUR
Option premium:
3 EUR
Underlying
Break-Even
Point: 53 EUR
Short Call
Loss

Long Put


Profit
Strike price: 50 EUR
Underlying
Break-Even
Point: 47 EUR
Option premium:
3 EUR
Long Put
Loss

Short Put


Profit
Strike price: 50 EUR
Short Put
Option premium:
3 EUR
Underlying
Break-Even
Point: 47 EUR
Loss

Options

	Basic assumption	Deal specifics
Long call	Price of underlying will go up	Must pay premium, can possibly buy underlying asset
Short call	Price of underlying will remain constant or drop slightly	Receives writer's premium and must possibly deliver
Long put	Price of underlying will go down	Must pay premium, can possibly sell underlying asset
Short put	Price of underlying will remain constant or go up slightly	Receives writer's premium and must possibly buy underlying asset

Options

Position	Market price of underlying	Volatility	Effect on time value
Long call	↑	↑	–
Short call	↓	↓	+
Long put	↓	↑	–
Short put	↑	↓	+

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Delta Hedge

Calculating the hedge ratio:

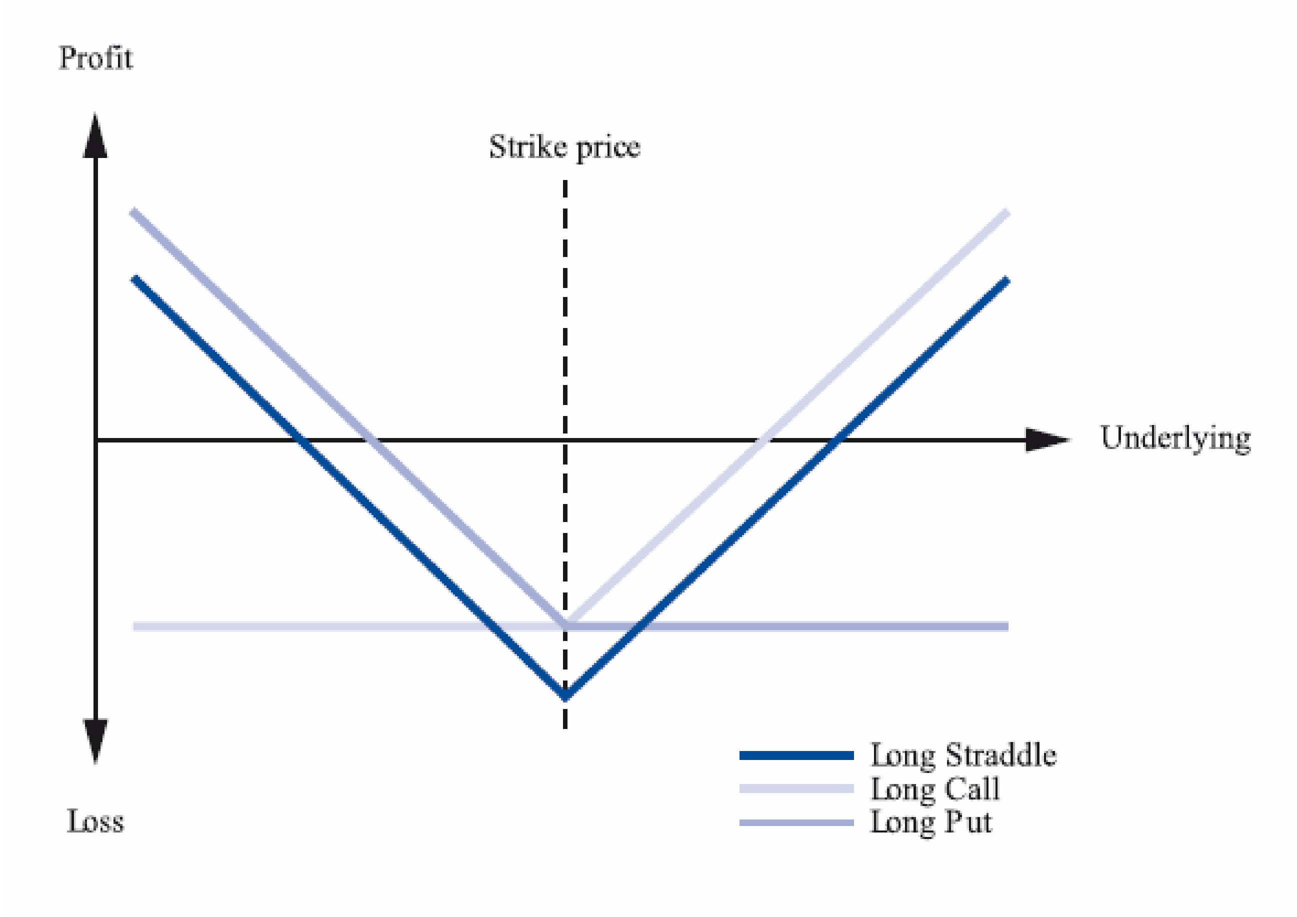
$$\# \text{ of contracts} = \frac{\text{Number of shares}}{\text{Contract size}} \times \frac{1}{\text{delta of option}}$$

Beta Hedge

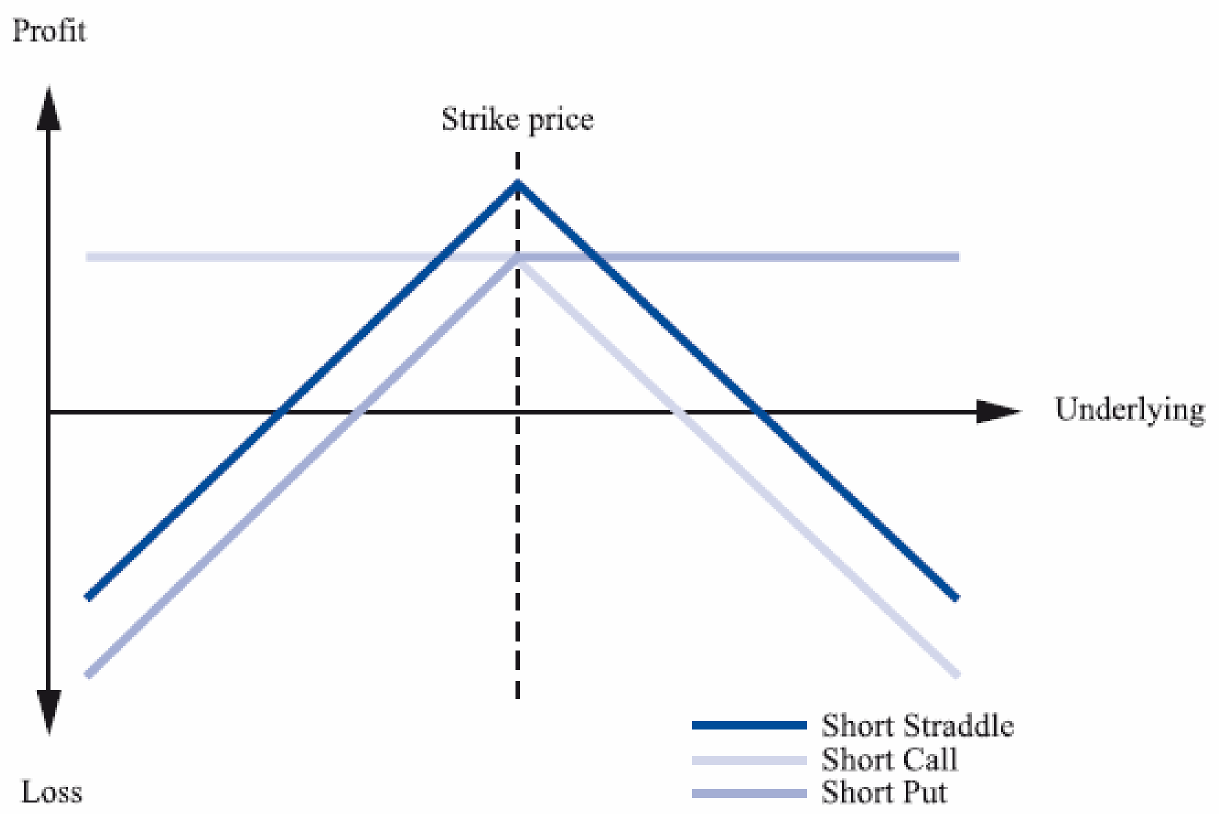
Hedge ratio for a β hedge: The number of contracts is determined using the following formula:

$$\#\ of\ contracts = \frac{Equivalent\ of\ the\ Portfolio}{\left(Index\,level \times contract\ size\ of\ indexoption\right)} \times \beta - portfolio$$

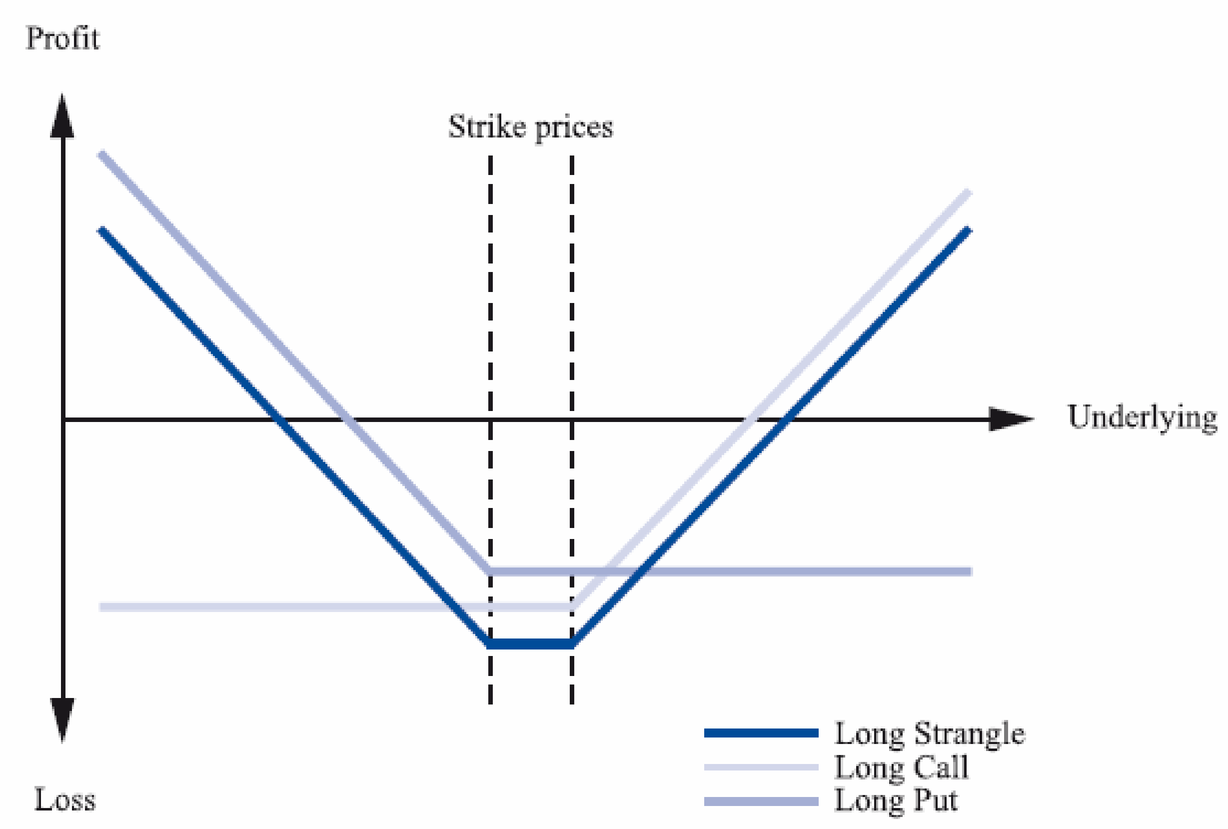
Long Straddle



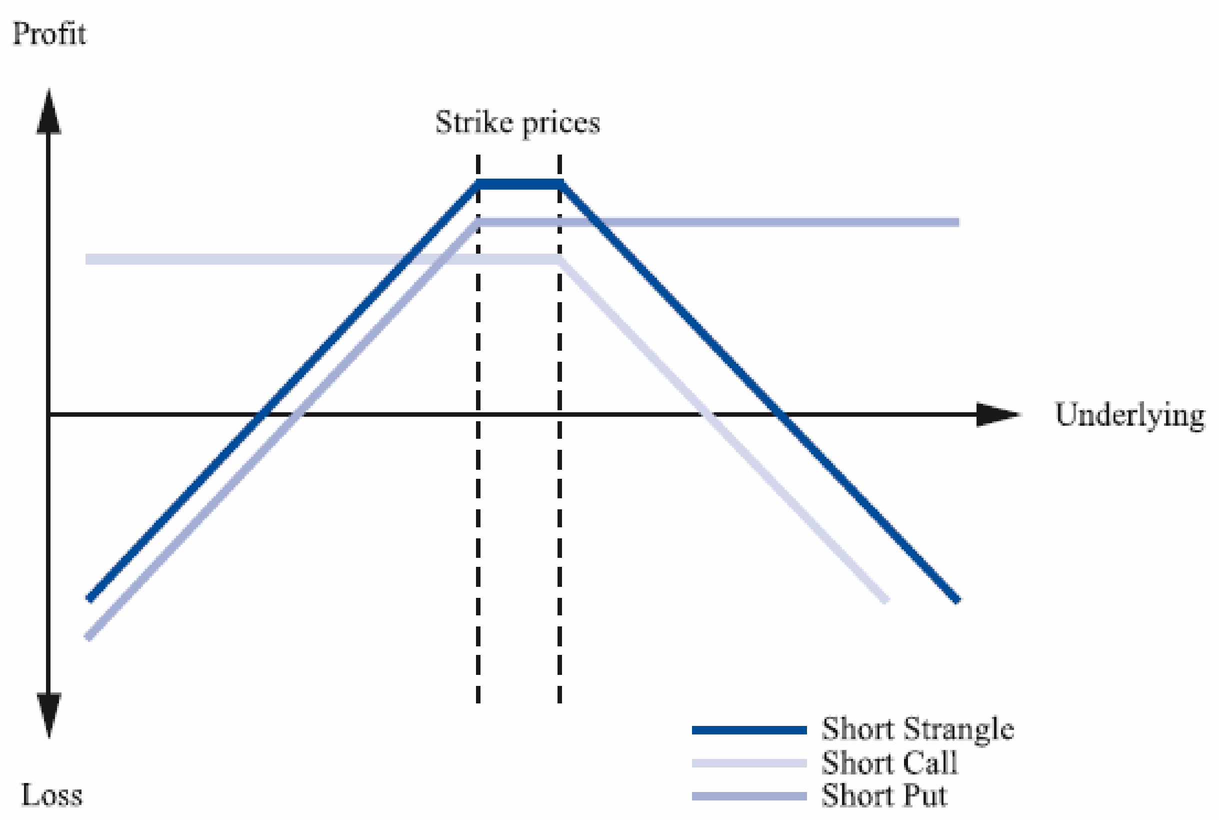
Short Straddle



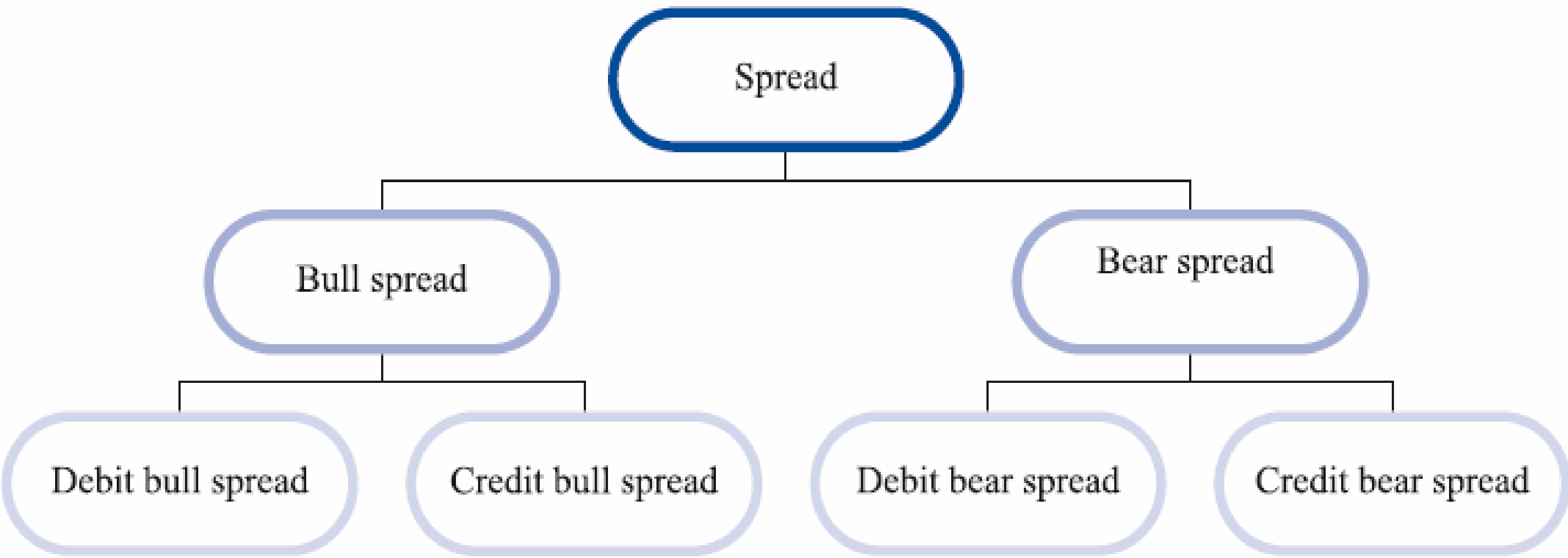
Long Strangle



Short Strangle



Spreads


Spread
Bull spread
Bear spread
Debit bull spread
Credit bull spread
Debit bear spread
Credit bear spread

Strategy

Market expectation	Option position	Potential profit	Potential loss
Strong increase	**Long call** + Call 30	unlimited	Maximum: Premium paid
Slight increase	**Purchase bull spread** + call 30 – call 35	Maximum: Difference in strike prices minus net premium expenditure	Maximum: Net premium expenditure
Slight increase	**Short put** – put 30	Maximum: premium paid	Almost unlimited

Strategy

Market expectation	Option position	Potential profit	Potential loss
Sideways move	**Sale of bear spread** + put 36 – put 40	Maximum: Net premium proceeds	Maximum: Difference in strike prices minus net premium proceeds
Sideways move	**Sale of bull spread** + call 40 – call 36	Maximum: Net premium proceeds	Maximum: Difference in strike prices minus net premium proceeds

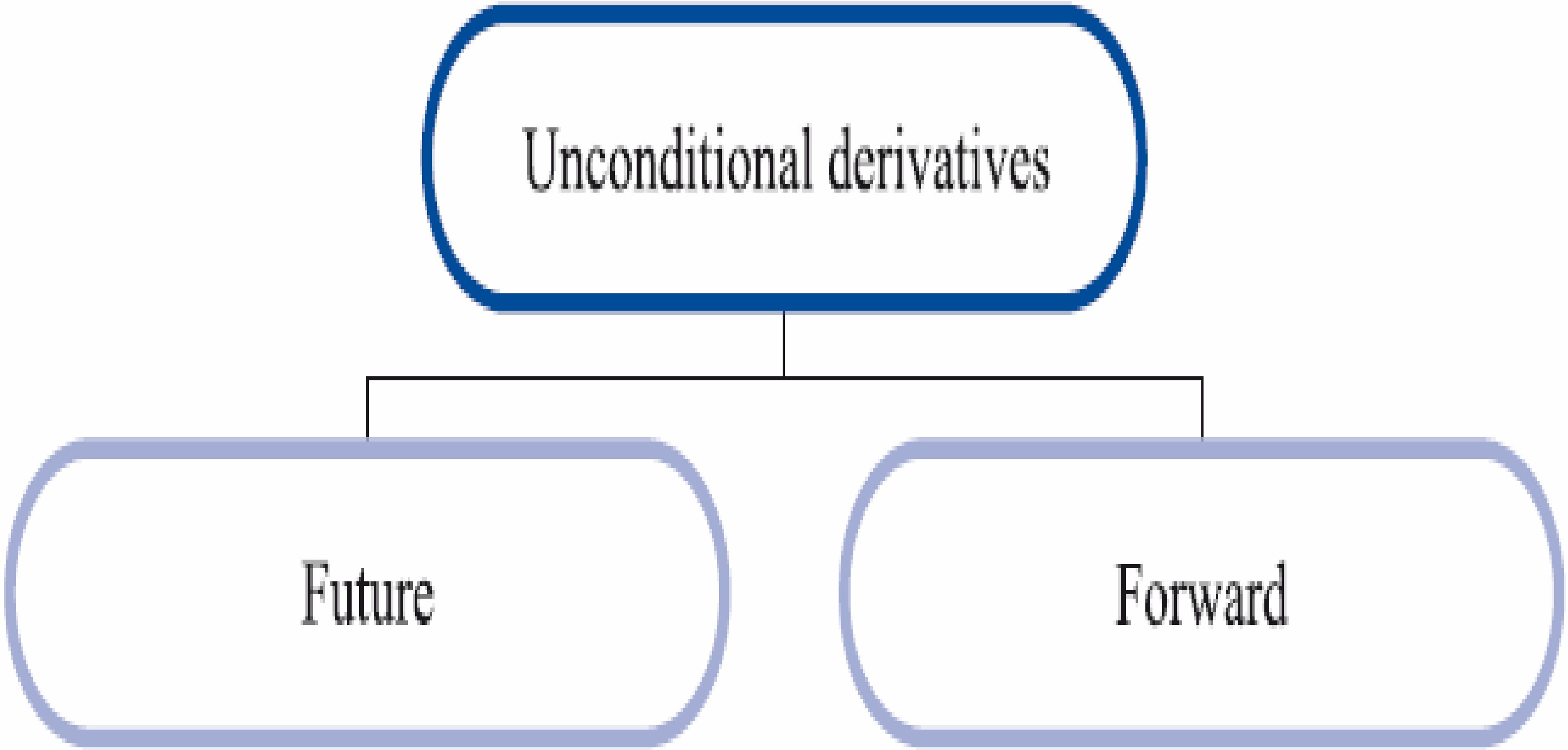
Strategy

Market expectation	Option position	Potential profit	Potential loss
Slight decrease	**Short call** – Call 40	Maximum: premium received	unlimited
Slight decrease	**Purchase of bear spread** + put 36 – put 32	Maximum: Difference in strike prices minus net premium expenditure	Maximum: Net premium expenditure
Strong decrease	**Long put** + put 36	Almost unlimited	Maximum: premium paid

Strategy

Market expectation	Option position	Maximum profit	Potential loss
Strong fluctuation	**Long straddle** + put 36 + put 36	Almost unlimited	Limited to premium paid
Very high fluctuation	**Long strangle** + call 38 + put 34	Almost unlimited	Limited to premium paid
Fluctuating around strike prices	**Short straddle** – Call 36 – put 36	Maximum: premium received	Almost unlimited
Fluctuating between strike prices	**Short strangle** – Call 38 – put 34	Maximum: premium received	Almost unlimited

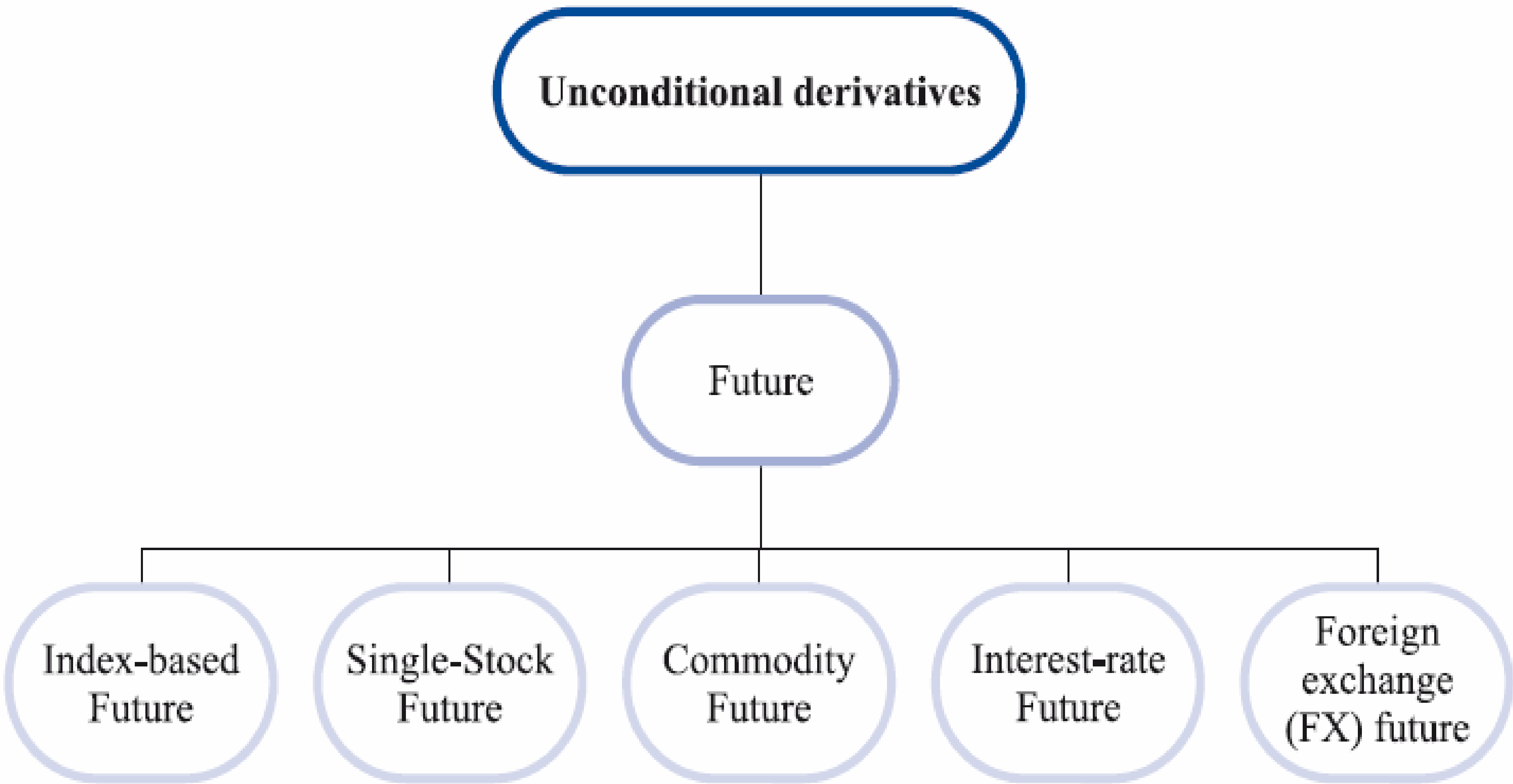
Future



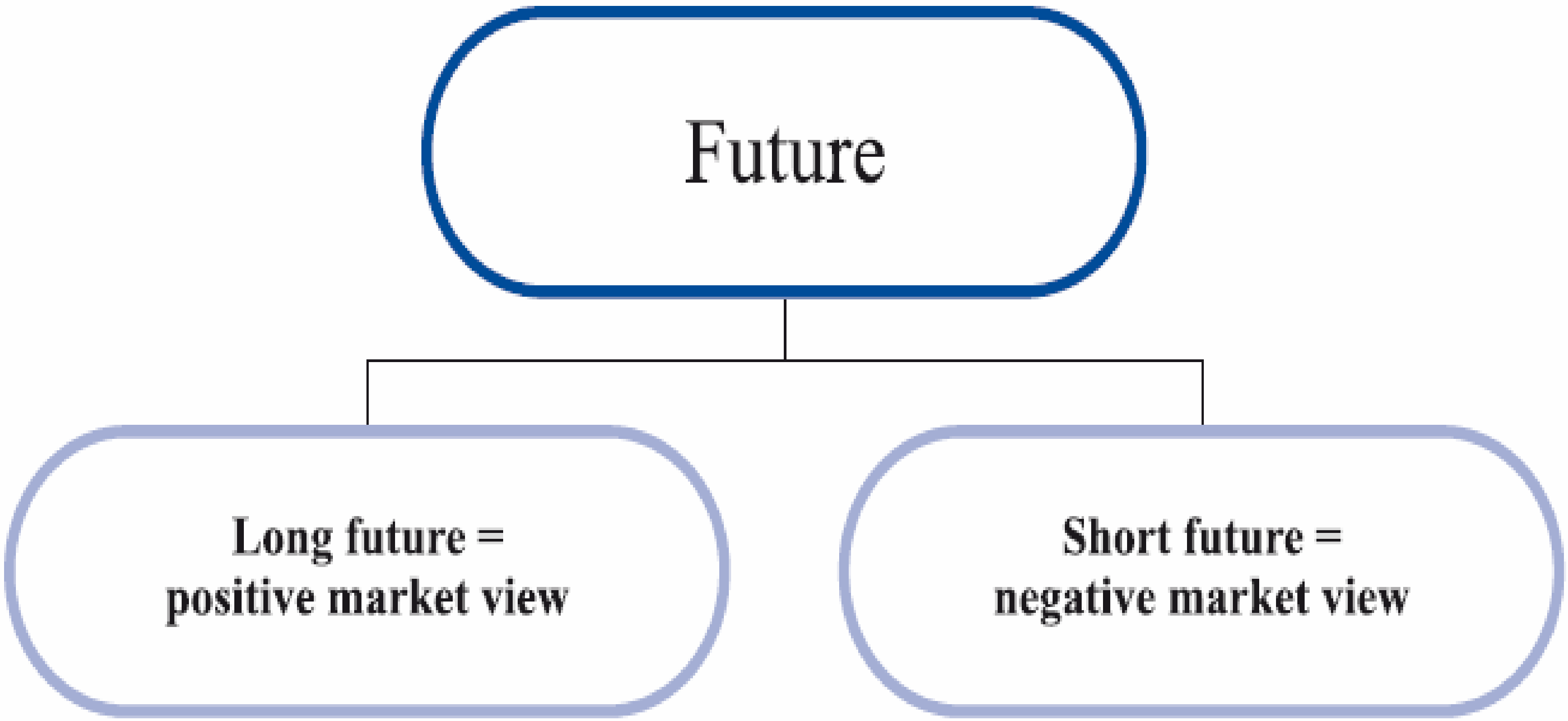
Future

By definition, a future is a derivative instrument comprising an obligation to purchase (long) or deliver (short) a certain underlying at a predefined price, at a fixed date, and in a particular (also predefined) quality and quantity. There is no right of choice. The transaction must be completed.

Future


Unconditional derivatives
Future
Index-based Future
Single-Stock Future
Commodity Future
Interest-rate Future
Foreign exchange (FX) future

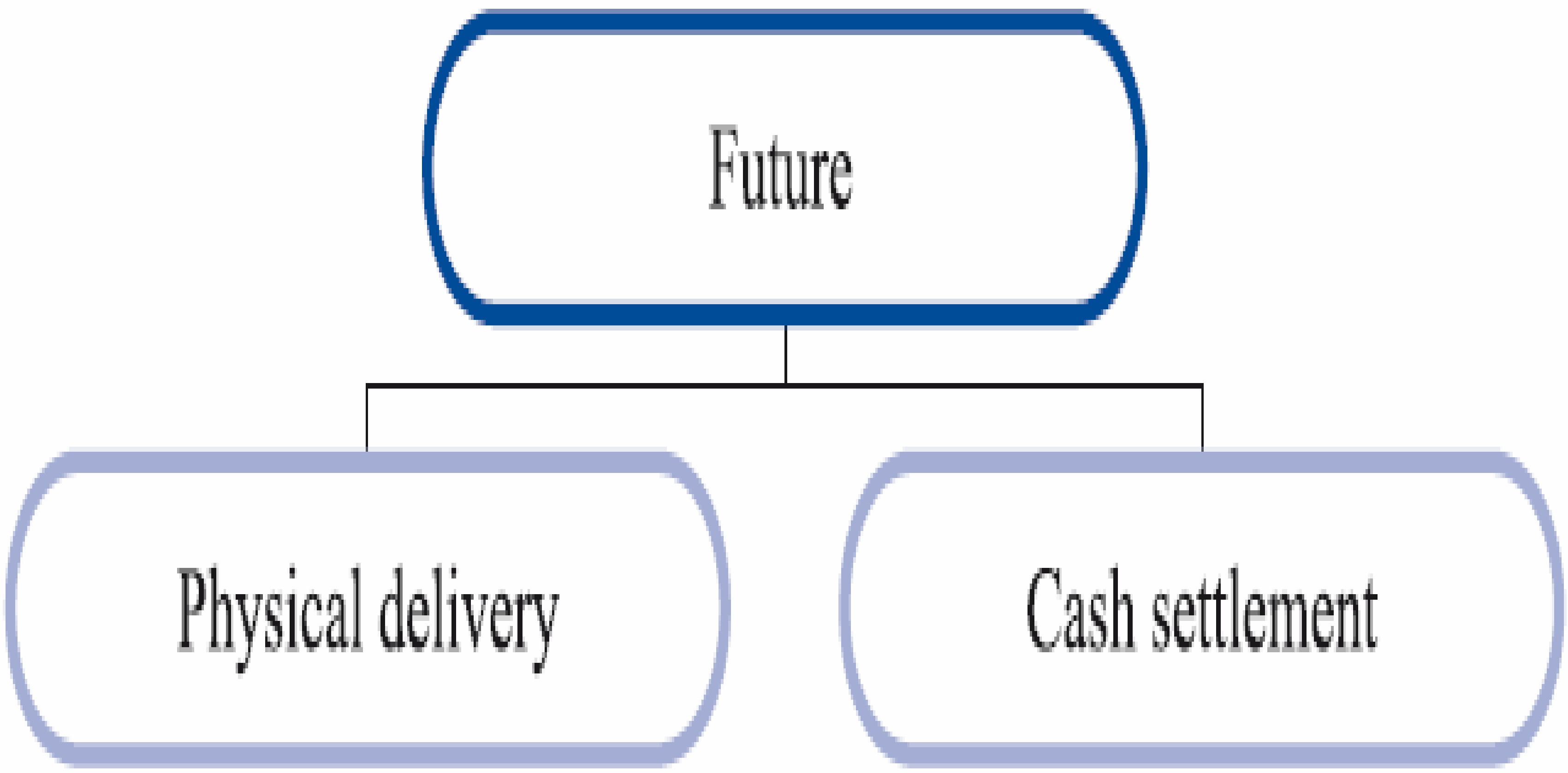
Future


Future
Long future =
positive market view
Short future =
negative market view

Opening vs. Closing

Opening	BUY FUTURE (long)
Closing	SELL FUTURE (short)
Opening	SELL FUTURE (short)
Closing	BUY FUTURE (long)

Settlement



Future position

Futures position	Basic assumption
Long future	Upward markets
Short future	Downward markets

Futures

Futures	Maturity of underlying instrument (years)
Euro Schatz Futures (€)	1.75 – 2.25, federal bonds
Euro Bobl Futures (€)	4.5 – 5.5, federal bonds
Euro Bund Futures (€)	8.5 – 10.5, federal bonds
Euro Buxl® Futures (€)	24.0 – 35.0, federal bonds
CONF Futures (CHF)	8.0 – 13.0, Swiss Confederation
T-Bill Futures (USD)	Three-month U.S. treasury bills
10 Year U.S. Treasury Note Futures (USD)	10-year U.S. government bonds
30 Year U.S. Treasury Note Futuers (USD	30-year U.S. government bonds

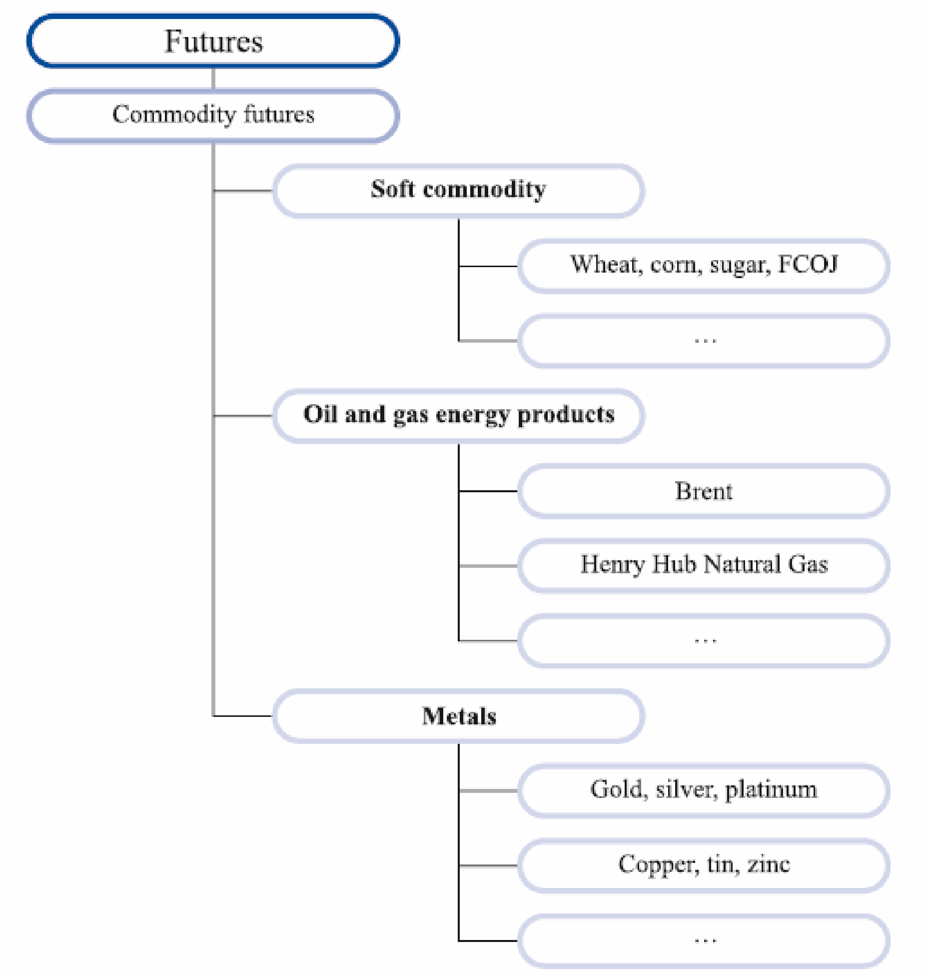
IR-futures

Futures position	Basic assumption	Settlement
Long future	Falling interest rates; rising bond prices	Must buy bonds
Short future	Rising interest rates; falling bond prices	Must sell bonds

FX-futures

€	USD
€	CHF
€	YEN
GBP	USD
AUD	USD
...	...

Commodity futures



Single Stock Future

Futures position	Basic assumption
Long future	Rising share price
Short future	Falling share price

State of the market

Open interest	Prices	Sales	State of the market
↑	↑	↑	↑
↓	↑	↓	↓
↑	↓	↑	↓
↓	↓	↓	↑

Future price

Theoretical future price = underlying + (financing cost − lost yields)

$$Future\,Preis = C_t + \left(C_t \times r_c \times \left(\frac{T-t}{360} \right) - d_{t,T} \right)$$

Where:

C_t = Underlying instrument (e.g., index level)

r_c = Money market interest rate (percent, current/360)

t = Valuta of spot market positions

T = Fulfillment day of a future

$T-t$ = Remaining term of a future

$d_{t,T}$ = Dividend payment expected for the period t to T

Future price

$$\text{Basis} = \text{future price} - \text{spot price}$$

Future basis

The spot price is...	The future price is...	The basis is...
… lower than the future price	… higher than the spot price	negative
… higher than the future price	… lower than the spot price	positive

Pricing IR - future

$$F = \left(\frac{U}{P}\right) - Z + C$$

Where:
F = future price
U = cash position
P = price factor
Z = coupon yield
C = financing cost of cash position

$$\left(\frac{U}{P}\right) - F = Z - C$$

Where:
F = future price
U = cash position
P = price factor
Z = coupon yields
C = financing cost of cash position

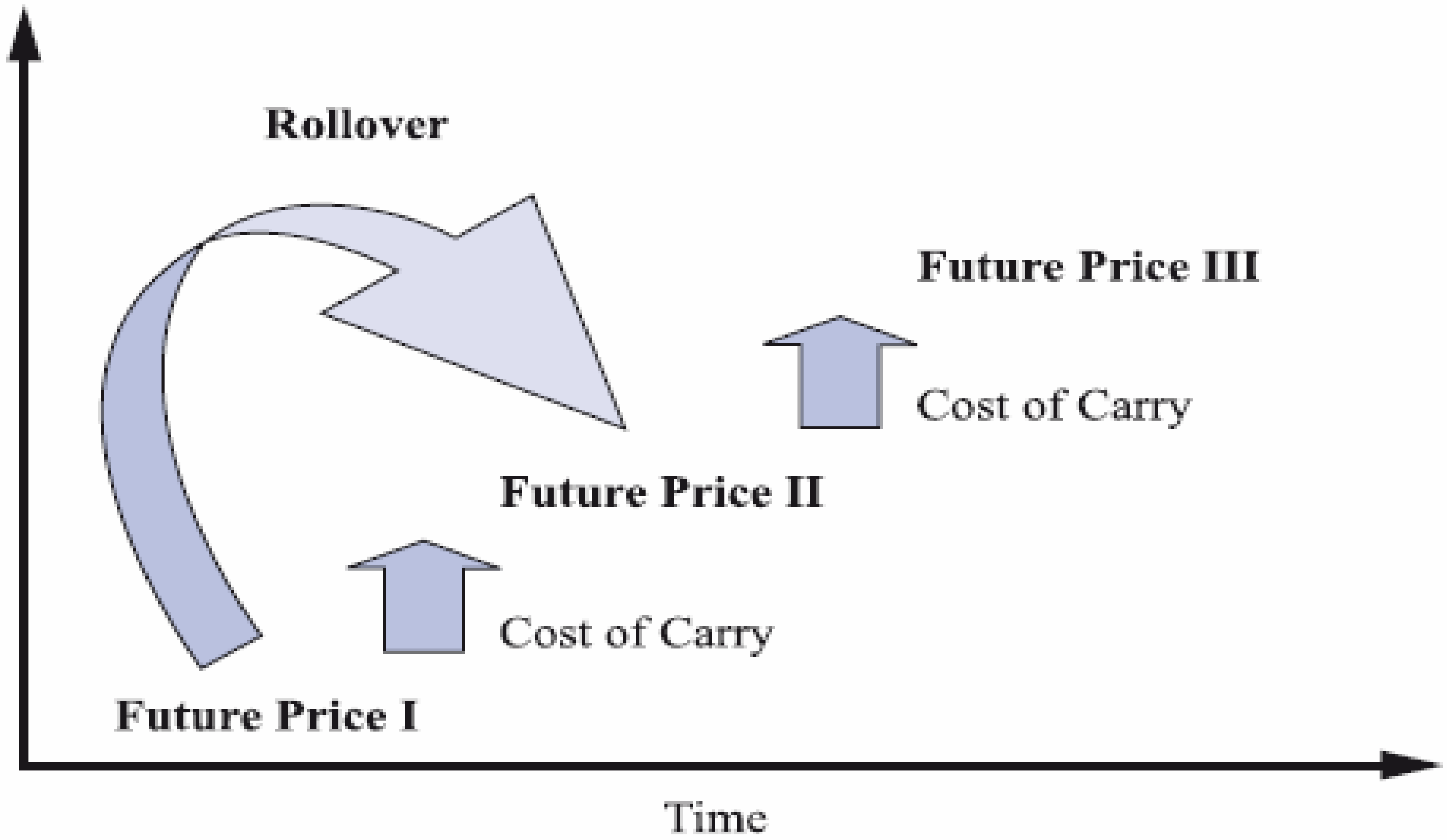
IR- Future

Final settlement price = Settlement price of future × nominal × price factor + interests accured

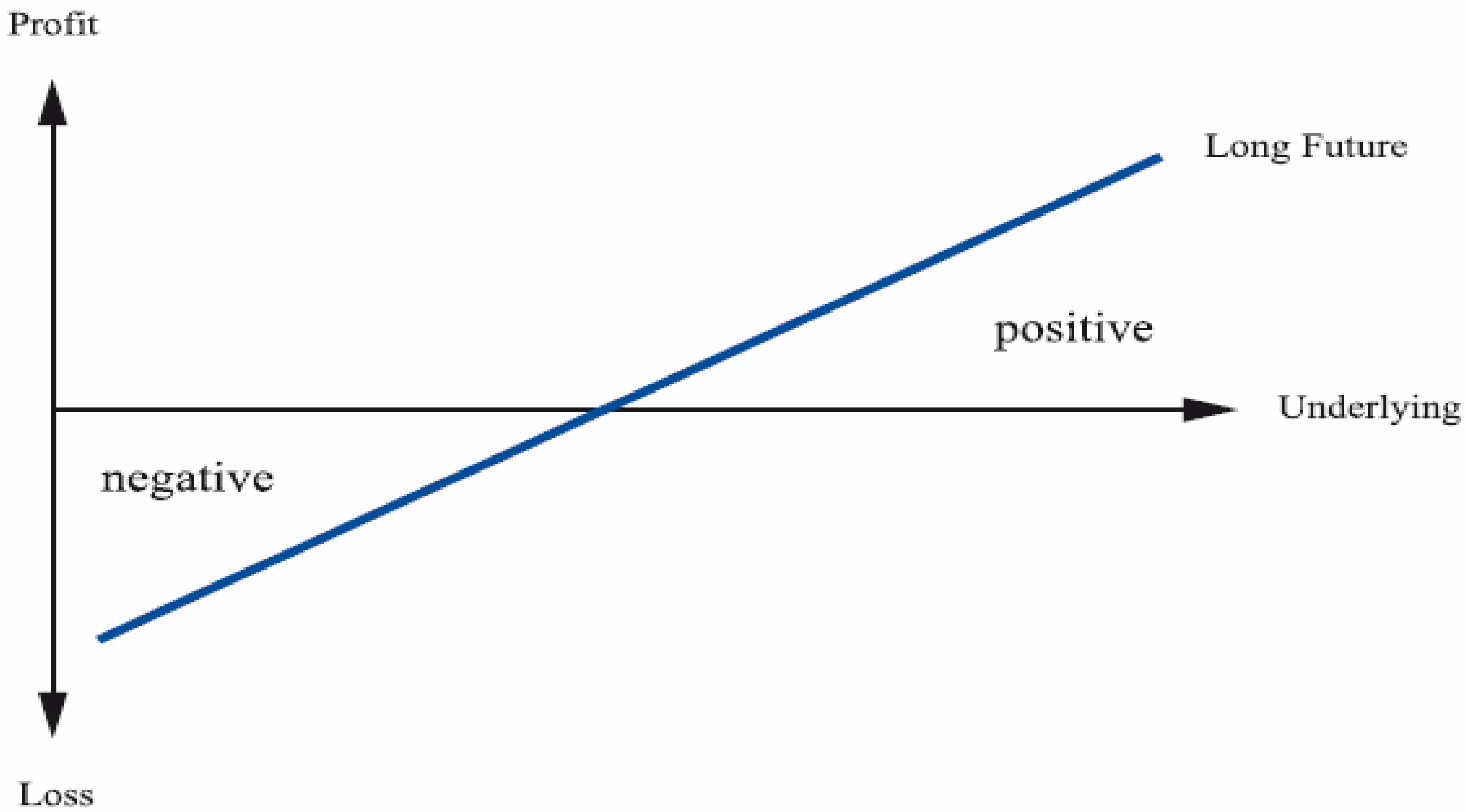
Maturity

1st possibility	March	June	September
2nd possibility	June	September	December
3rd possibility	September	December	March
4th possibility	December	March	June

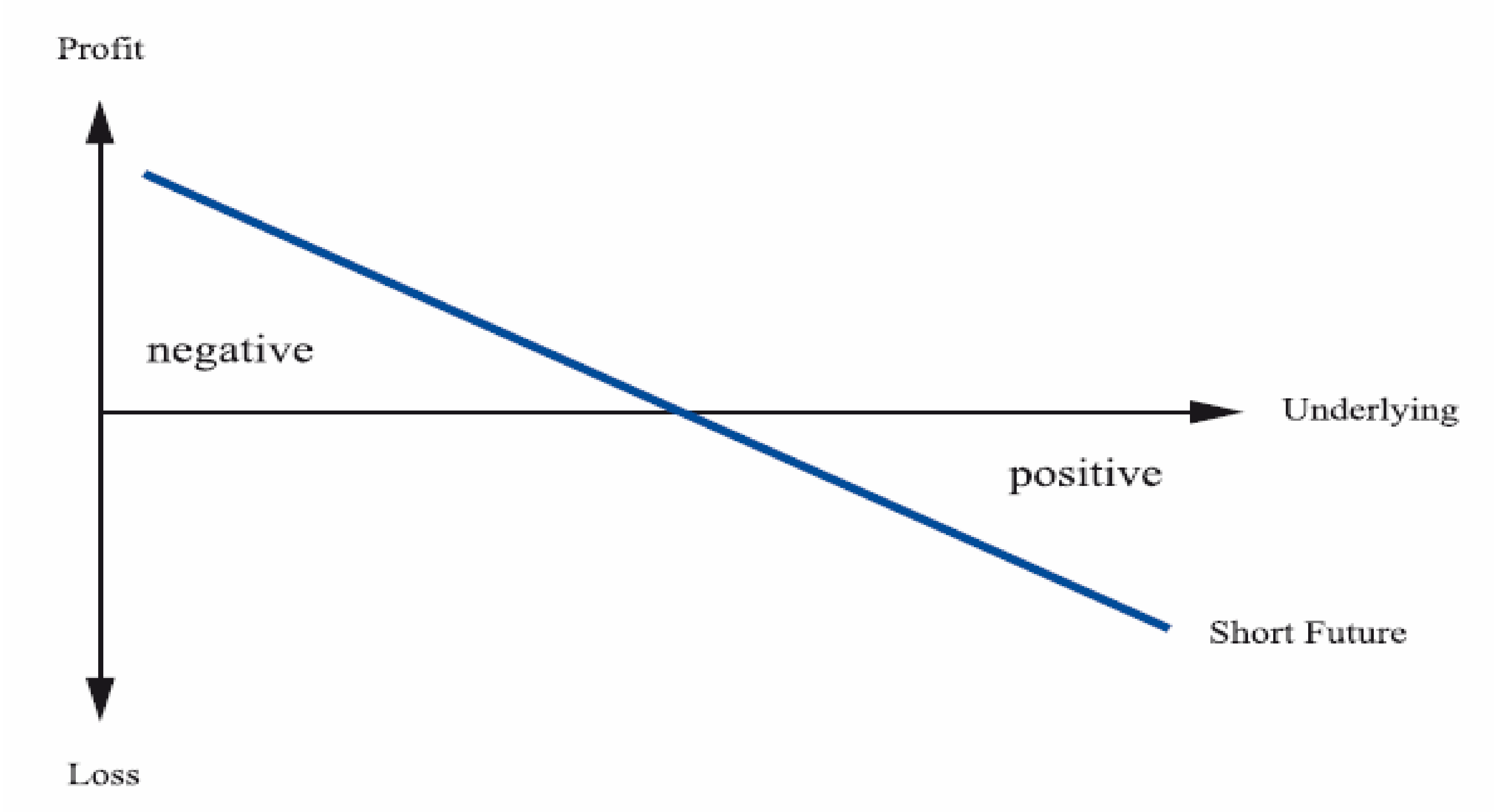
Rollover


Rollover
Future Price III
Cost of Carry
Future Price II
Cost of Carry
Future Price I
Time

Long Future



Short Future



Hedges

$$Hedge\ Ratio = \frac{Portfolio}{Index - future - points} \times \frac{1}{index\ multiplier}$$

Spreads

Type of index	Rising prices	Falling prices
Performance index	Sale of a spread	Purchase of a spread
Price index cost of carry > 0	Sale of a spread	Purchase of a spread
Price index cost of carry < 0	Purchase of a spread	Sale of a spread

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Cash and Carry and Reverse

Cash and carry → sale of futures and purchase of spot market product
Reverse cash and carry → purchase of futures and sale of spot market product

Beta

Value	Meaning
Beta $(\beta) = 1$	Stock behaves like market 1:1
Beta $(\beta) > 1$	Stock moves more than market
Beta $(\beta) < 1$	Stock moves less than market

Correlation

Value	Meaning
$r = +1$ Maximum positive correlation	There is a positive correlation (synchronism)
$r = 0$ Correlation is neutral	There is no (or a random) correlation
$r = -1$ Maximum negative correlation	Developments run (absolutely) contrary

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Beta Hedge

$$\#\ of\ futures\ contracts = -1 \times \left(\frac{value\ of\ portfolio}{(index\ level \times contract\ seize)} \right) \times \beta\ portfolio$$

IR Hedge

$$hedge\ ratio = \frac{nominal\ value_{Cash}}{nominal\ value_{Future}}$$

$$hedge\ ratio = \left(\frac{nominal\ value_{spot}}{nominal\ value_{future}}\right) \times \left(\frac{duration_{spot}}{duration_{future}}\right) \times PF_{CTD}$$

PF_{CTD} = Price Factor of CTD

$$hedge\ ratio = \left(\frac{nominal\ value_{spot}}{nominal\ value_{future}}\right) \times \left(\frac{\Delta_{spot,\,BP}}{\Delta_{CTD,BP}}\right) \times PF_{CTD}$$

The changes in value can be derived from the rate-of-return calculation

IR Hedge

$$hedge\ ratio = \frac{nominal\ value_{spot}}{nominal\ value_{future}} \times RK$$

$RK =$ Regression coefficient

Options on futures

Options contract	Future
Long call	Long future
Short call	Short future
Long put	Short future
Short put	Long future

Synthetic Combinations

Synthetic form of...	Combination of...		
	Call option	Put option	Future
Long call		Long	Long
Short call		Short	Short
Long put	Long		Short
Short put	Short		Long

Synthetic Combinations

Synthetic form of...	Combination of...		
	Call option	Put option	Future
Long future	Long	Short	
Short future	Short	Long	

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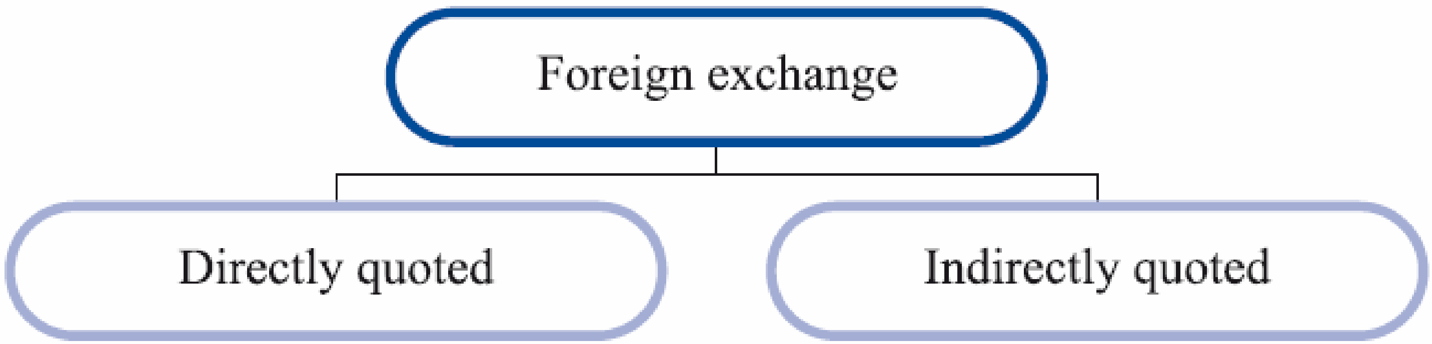
FX



FX

$$\text{Forward rate} = \text{spot rate} \times \frac{1 + \left(r_G \times \frac{T}{B_G}\right)}{1 + \left(r_Q \times \frac{T}{B_Q}\right)}$$

Where:

T = number of days

r_G = interest rate p.a. in decimals, base currency

r_Q = interest rate p.a. in decimals, target currency

B_G = Calculation basis for base currency (360 or 365)

B_Q = Calculation basis for target currency (360 or 365)

FX

$$Forward\ rate_{bid} = spot\ rate_{bid} \times \frac{1 + \left(r_{bid,G} \times \frac{T}{B_G}\right)}{1 + \left(r_{ask,Q} \times \frac{T}{B_Q}\right)}$$

$$Forward\ rate_{ask} = spot\ rate_{ask} \times \frac{1 + \left(r_{ask,G} \times \frac{T}{B_G}\right)}{1 + \left(r_{bid,Q} \times \frac{T}{B_Q}\right)}$$

Where:

T = number of days

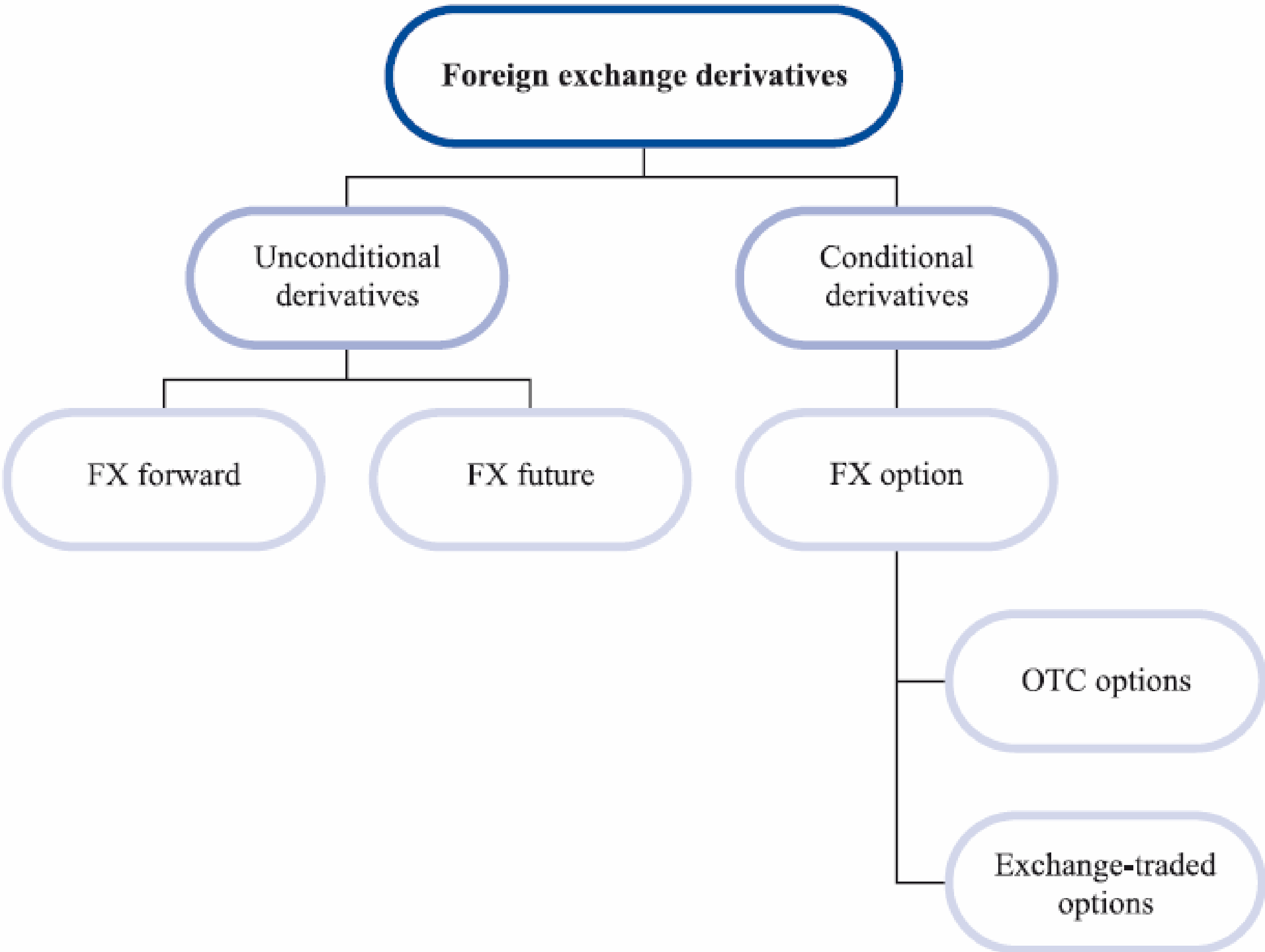
r_G = interest rate p.a. in decimals, base currency

r_Q = interest rate p.a. in decimals, target currency

B_G = Calculation basis for base currency (360 or 365)

B_Q = Calculation basis for target currency (360 or 365)

FX futures


Foreign exchange derivatives
Unconditional derivatives
Conditional derivatives
FX forward
FX future
FX option
OTC options
Exchange-traded options

SWAP rate

$$domestic\ interest\ rate\ activity = \left(1 + r \times \left(\frac{Duration\ (days)}{360}\right)\right)$$

Where r = Domestic interest rate

$$Foreign\ interest\ rate\ activity = \frac{1}{K_1} \times \left(1 + r_1 \times \left(\frac{duration\ (days)}{360}\right)\right) \times Forward\ rate$$

Where:
K_1 = spot rate
r_1 = Foreign interest rate

$$Foreign\ interest\ rate\ activity = \frac{1}{K_1} \times \left(1 + r_1 \times \left(\frac{duration\ (days)}{360}\right)\right) \times Forward\ rate$$

Where:
K_1 = spot rate
R = domestic interest rate
R_1 = foreign interest rate

Forward rate

$$\left(1+r\times\left(\frac{Duration\ (days)}{360}\right)\right)=\frac{1}{K_1}\times\left(1+r_1\times\left(\frac{Duration\ (days)}{360}\right)\right)\times Forward\ rate$$

$$Foraward\ rate=K_1\times\left[\frac{\left(1+r\times\left(\frac{Duration\ (days)}{360}\right)\right)}{\left(1+r_1\times\left(\frac{Duration\ (days)}{360}\right)\right)}\right]$$

Where:

K_1 = spot rate

R = domestic interest rate

R_1 = foreign interest rate

SWAP rate

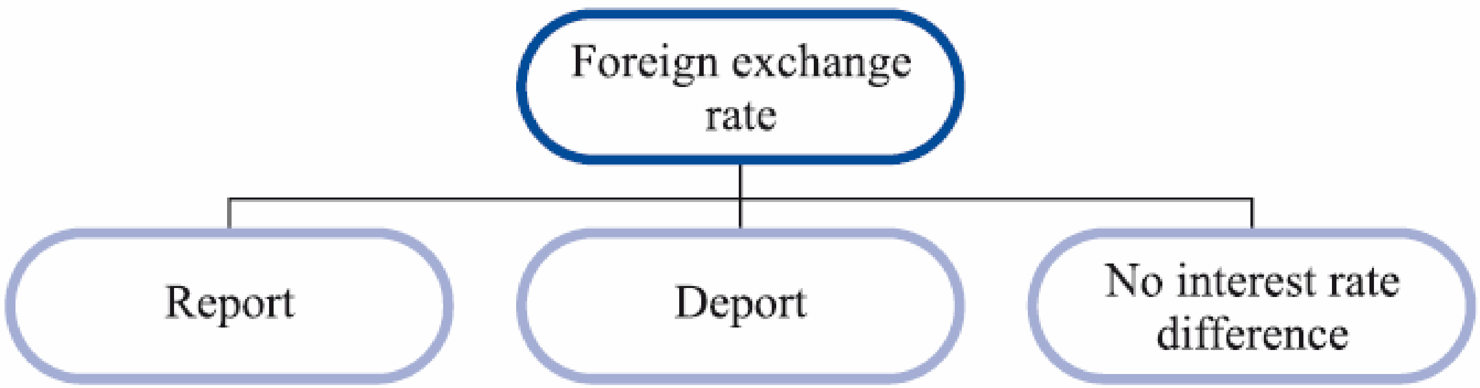
$$Swaprate = \frac{K_1 \times Z \times Duration\ (days)}{360}$$

Where:

K_1 = spot rate

Z = interest rate difference between currencies

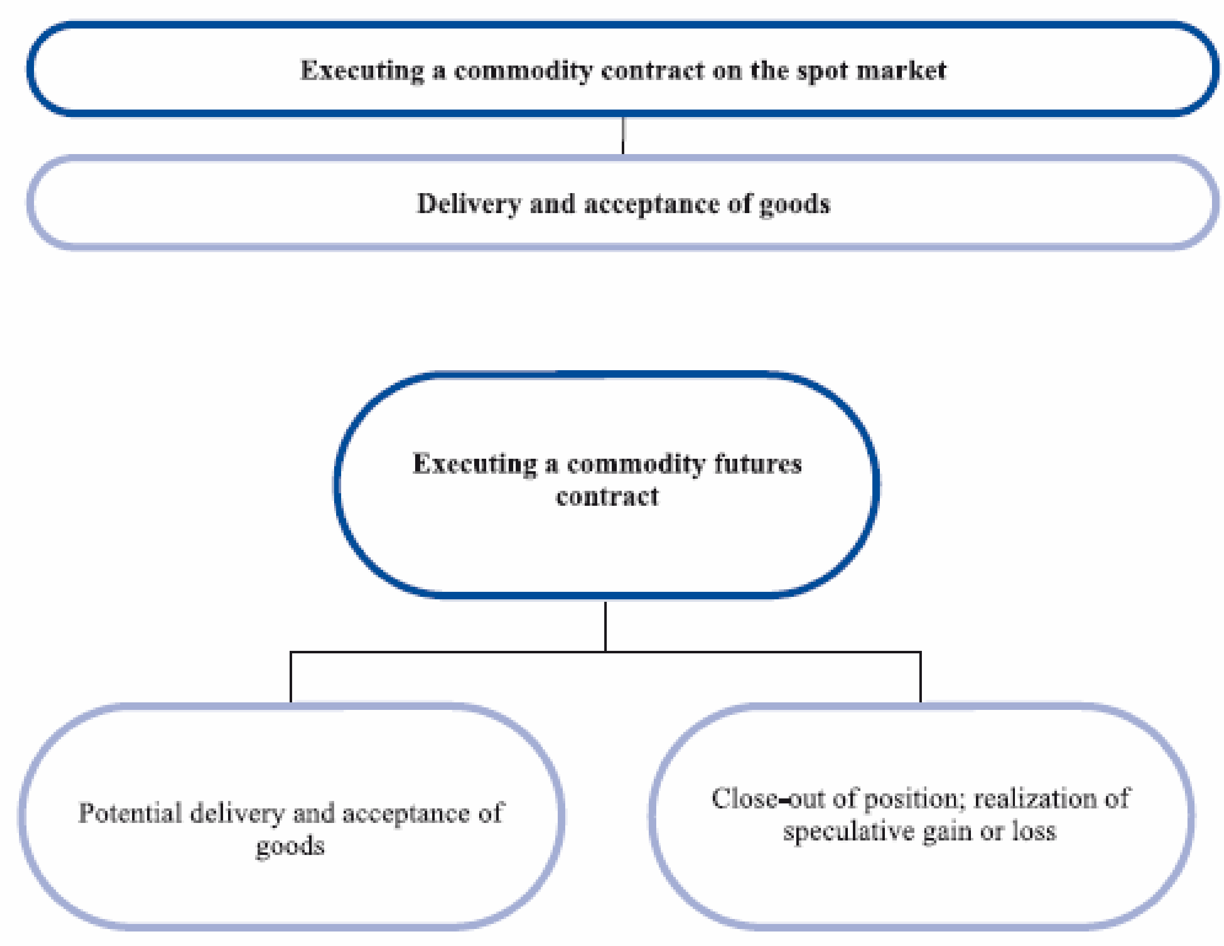
Deport and Report



fx-options

The buyer of a currency option acquires the right but not the obligation to buy or sell a certain amount in a foreign currency on a predefined date and at a predefined price. For this right he pays an option premium to the Writer (short).

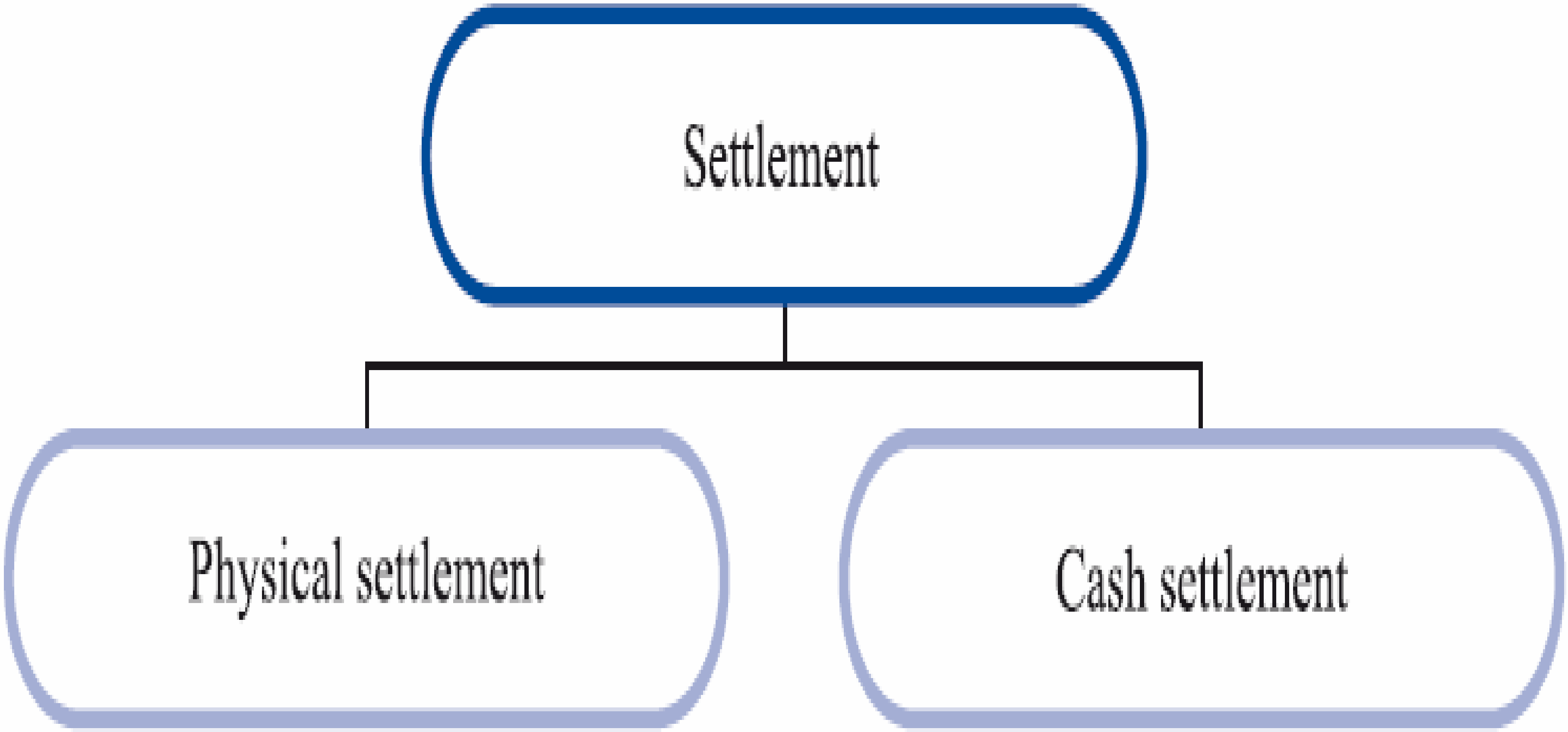
Commodity futures



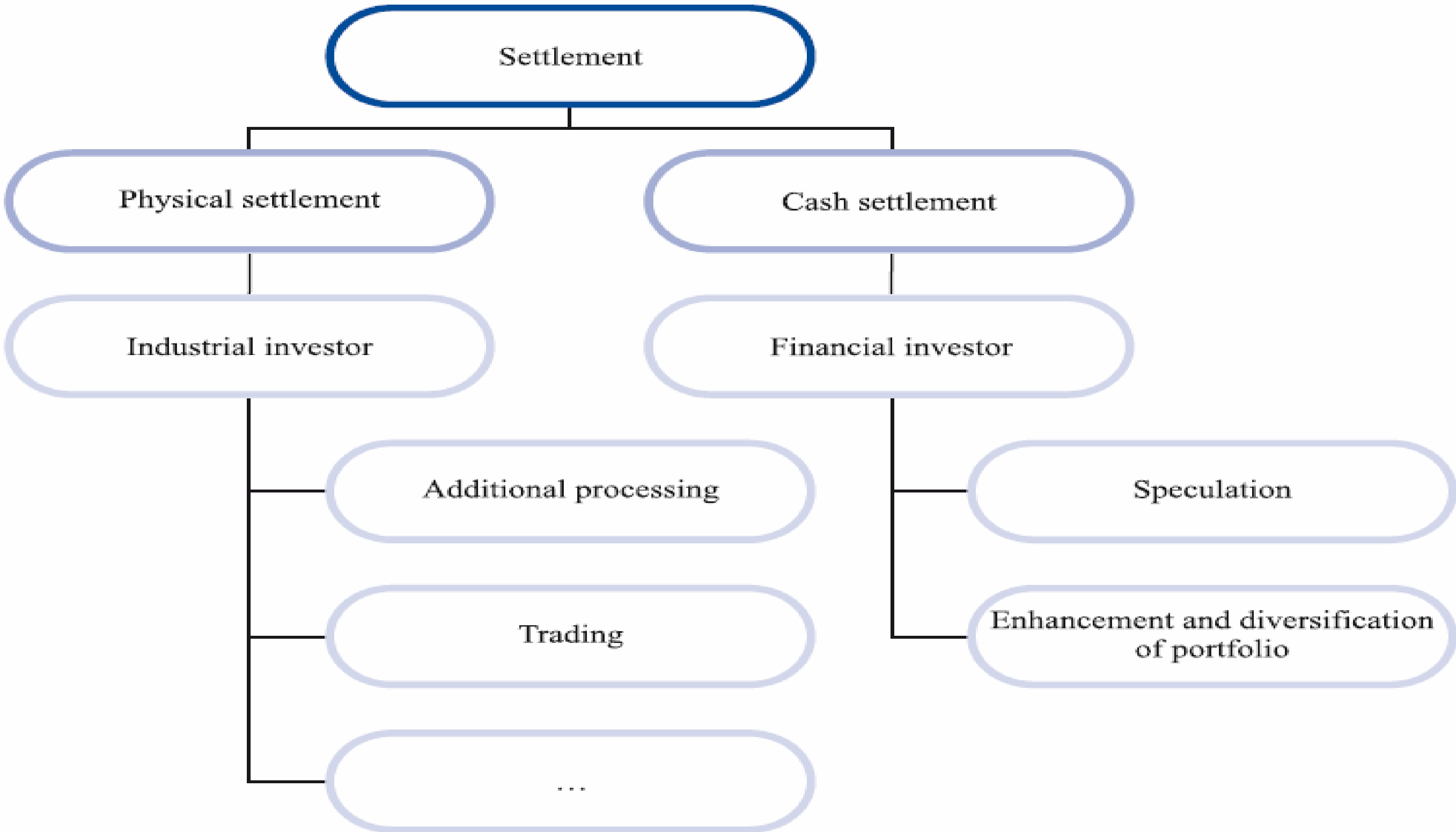
Opening vs. Closing

Opening	Close-out
Long future	Short future
Short future	Long future

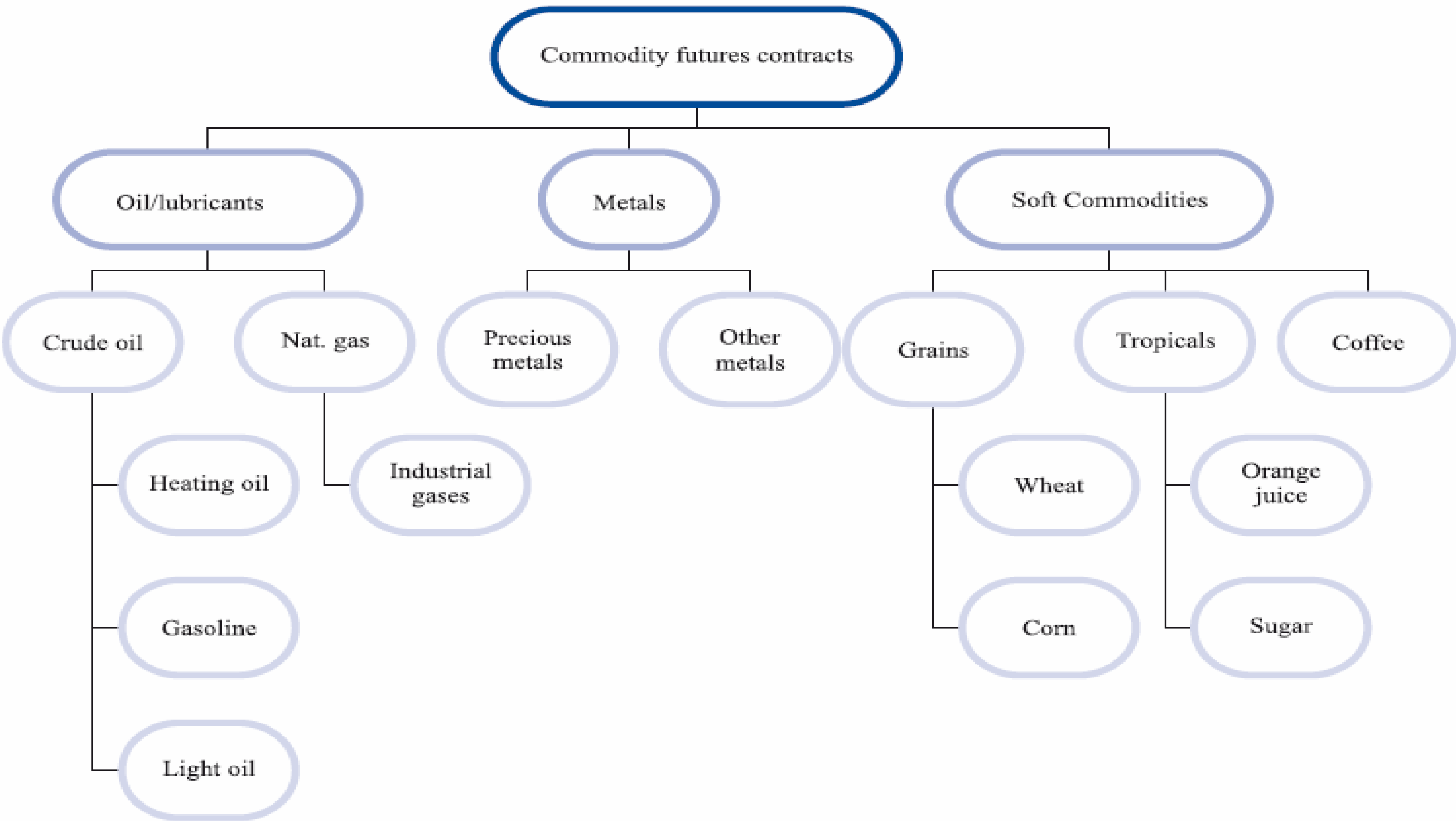
Settlement



Settlement

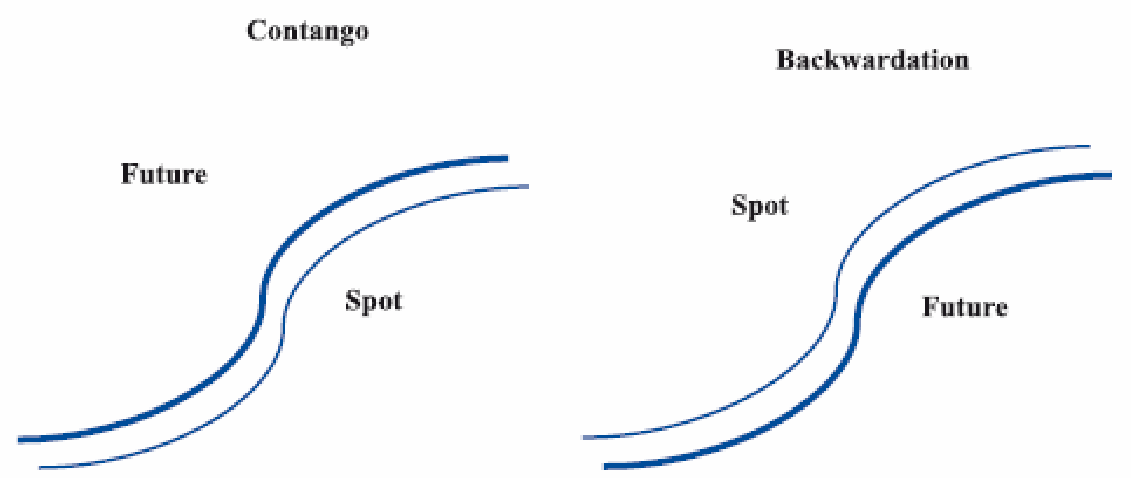

Settlement
Physical settlement
Cash settlement
Industrial investor
Financial investor
Additional processing
Trading
...
Speculation
Enhancement and diversification of portfolio

Commodity futures



Pricing of commodity futures

Commodity futures			
Spot price	<	Future price	Contango
Spot price	>	Future price	Backwardation



Pricing of commodity futures

$$F_0 = K_0 \times \frac{(1+i+L)^t}{(1+y)^t}$$

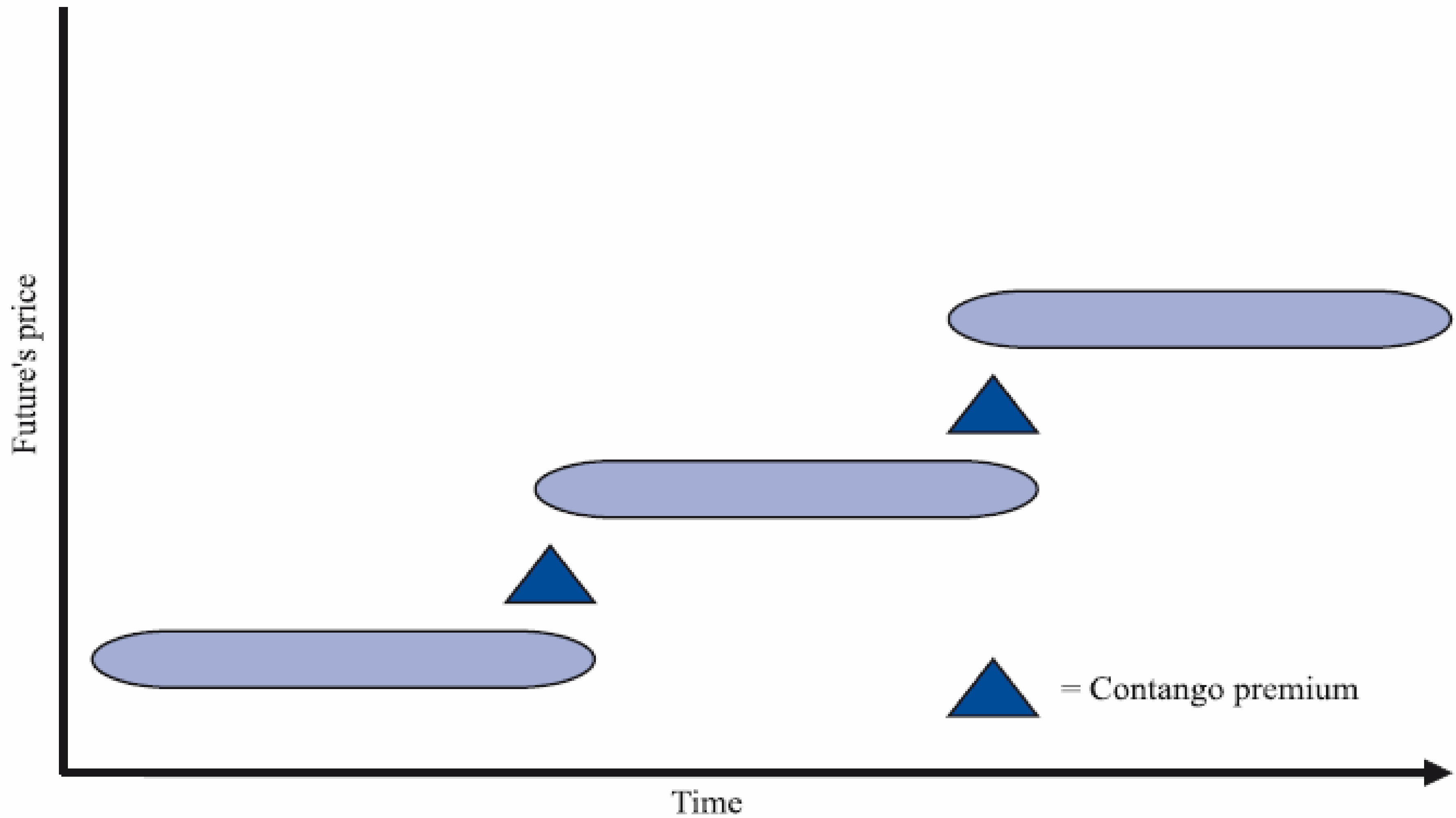
Where:
F_0 = Fair value
K_0 = Spot price
I = Cost of storage (net)
i = Risk-free rate of interest
y = Convenience yield
t = Maturity over years

$$F_0 \times (1+y)^t = (K_0 + L_0) \times (1+i)^t$$

$$F_0 \times (1+y)^t = K_0 \times (1+i+L)^t$$

Price of future =
price of commodity + ((financing cost + warehousing cost) − convenience yield)

Contango

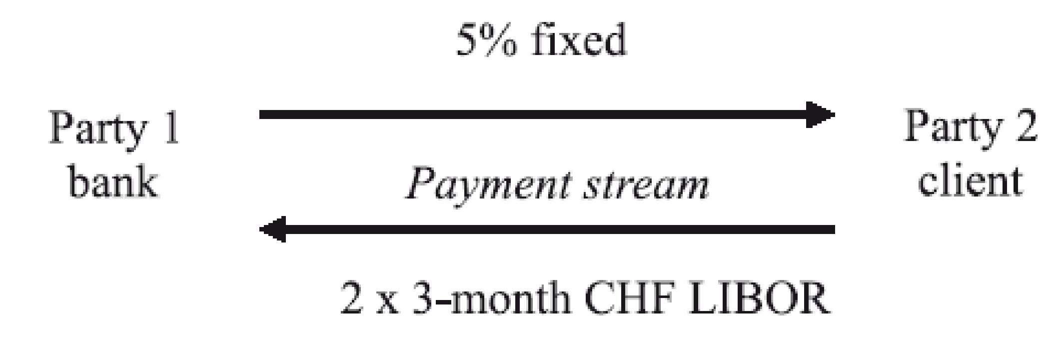


SWAP

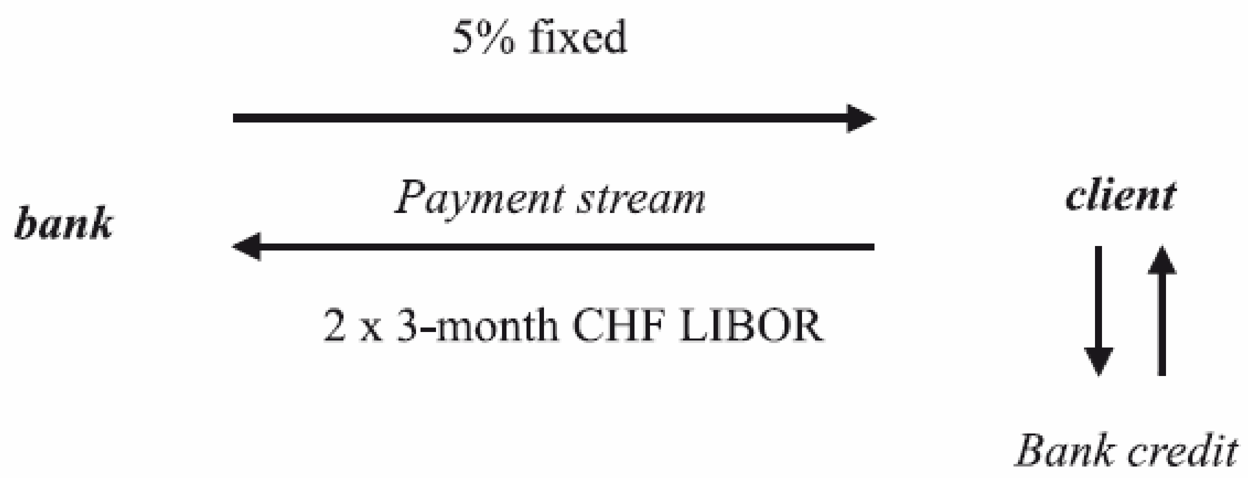
IR - Swap

Interest rate side	Designation
Fixed interest rate	Payor swap
Variable interest rate	Receiver swap

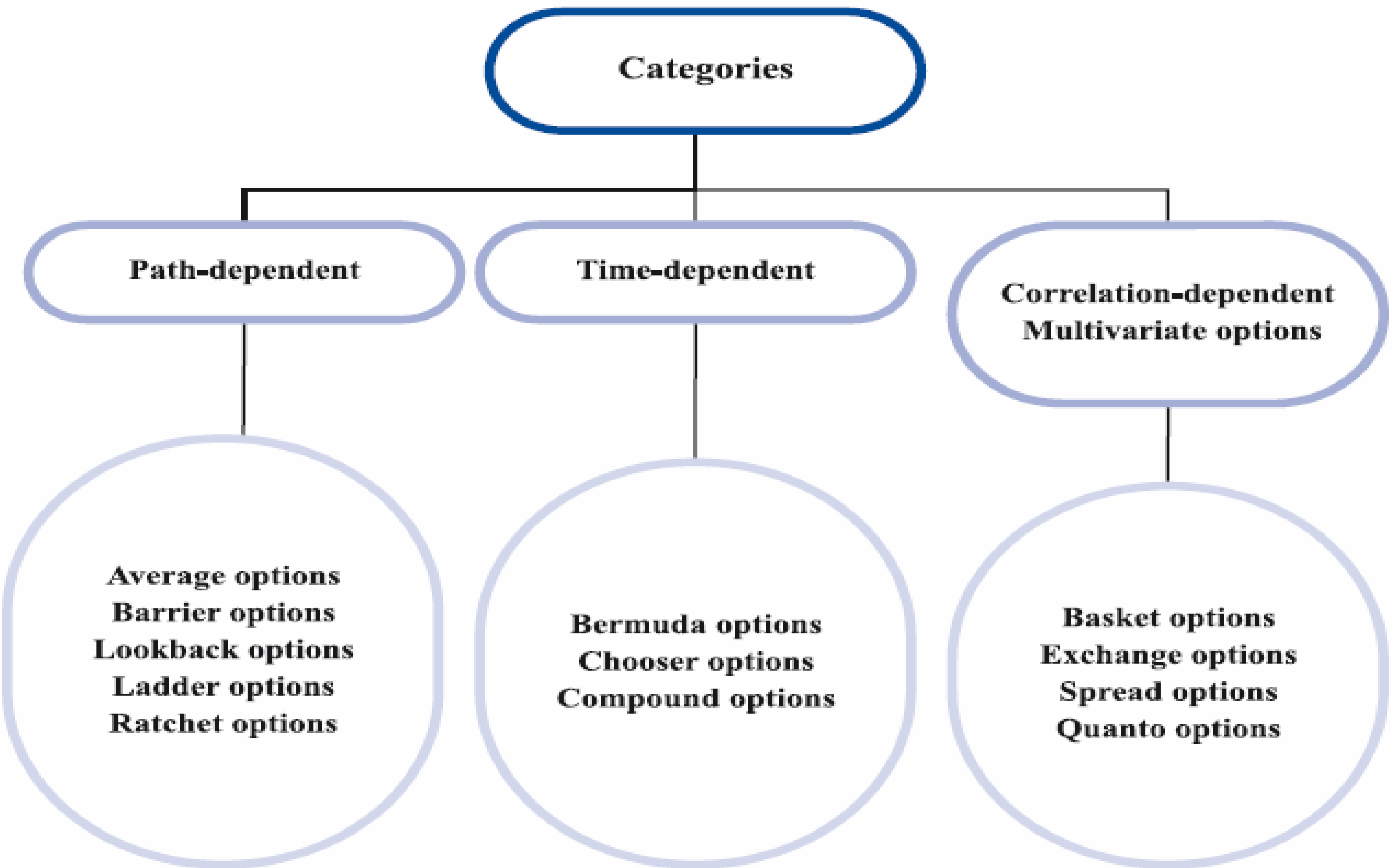
FX-SWAP


5% fixed
Party 1
bank
Payment stream
Party 2
client
2 x 3-month CHF LIBOR

SWAP


5% fixed
bank
Payment stream
client
2 x 3-month CHF LIBOR
Bank credit

Exotic options



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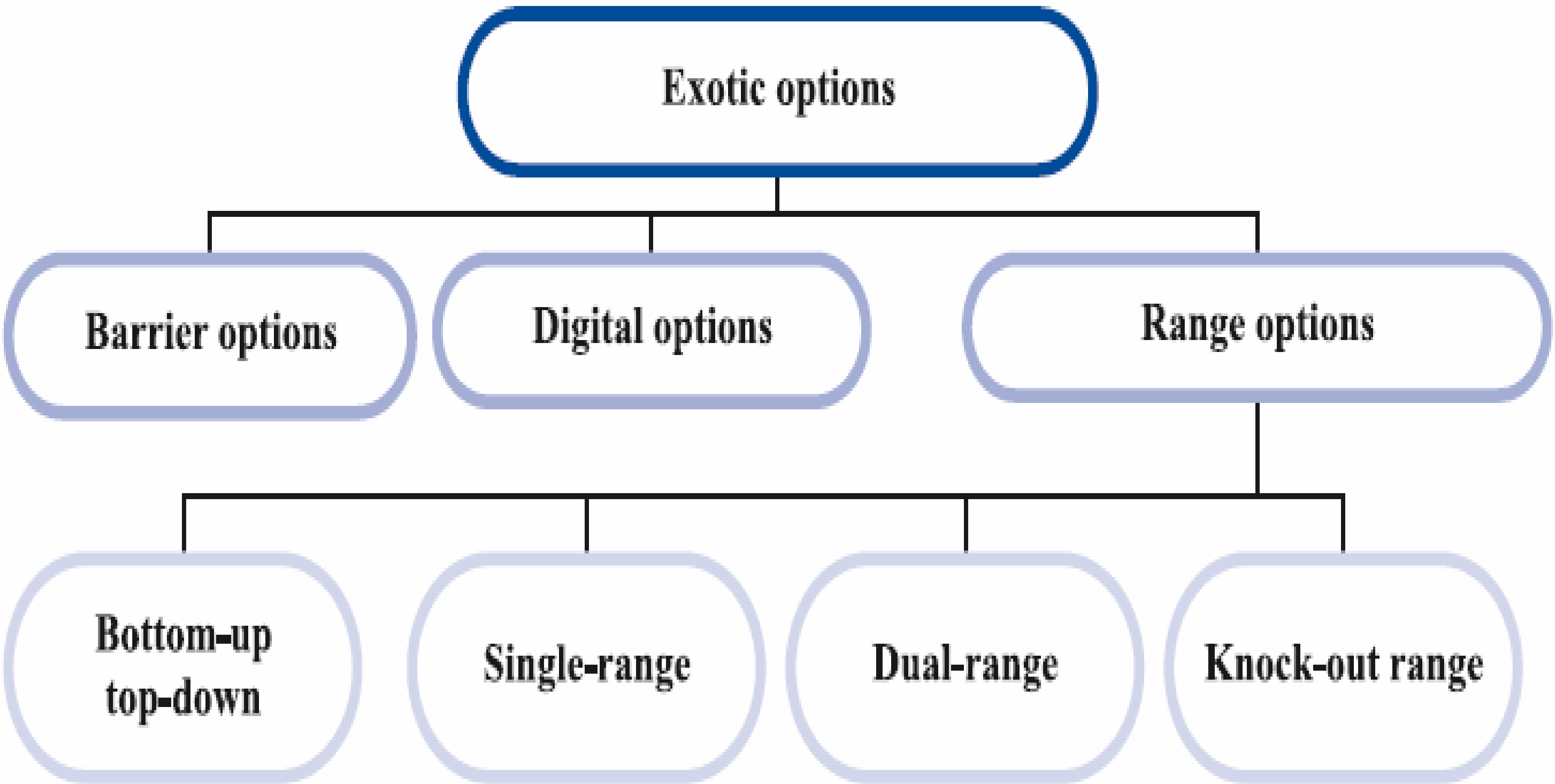
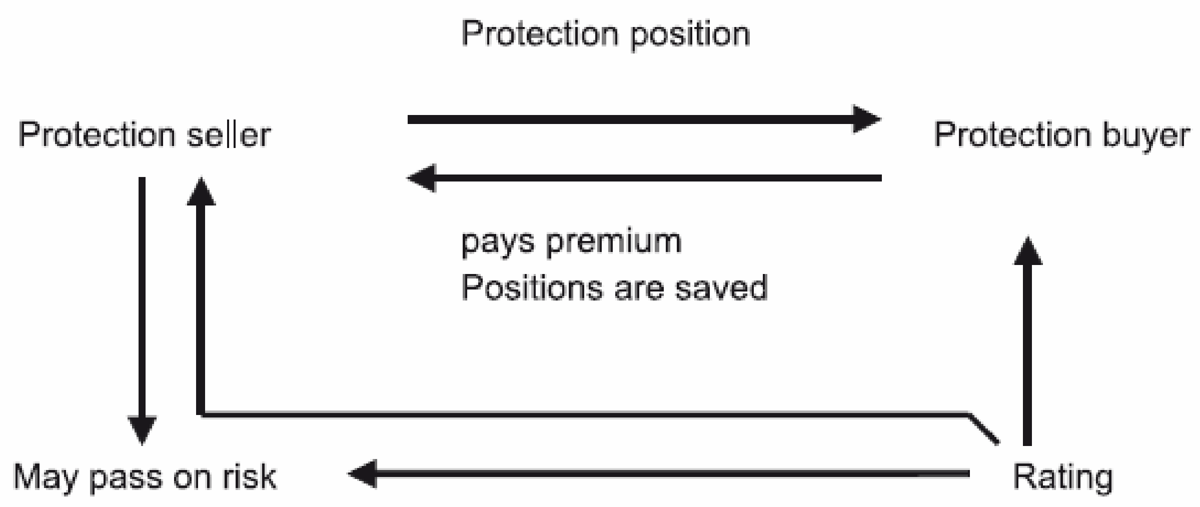
Exotic options



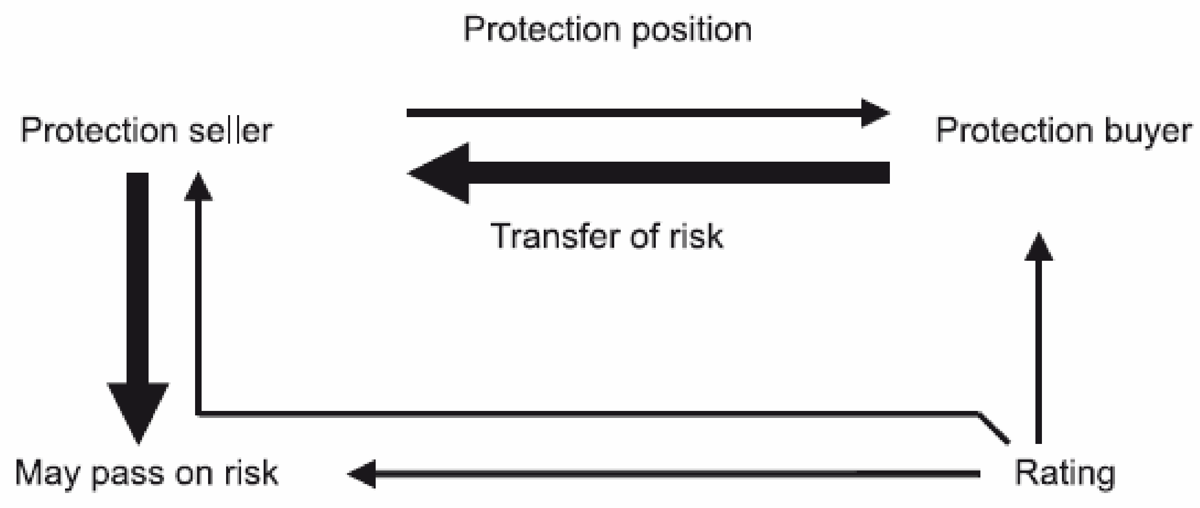
Knock In / Out

Event	Knock-in (option is activated)	Knock-out (option expires)
Underlying up	Up-and-in call / put	Up-and-out call / put
Underlying down	Down-and-in call / put	Down-and-out call / put

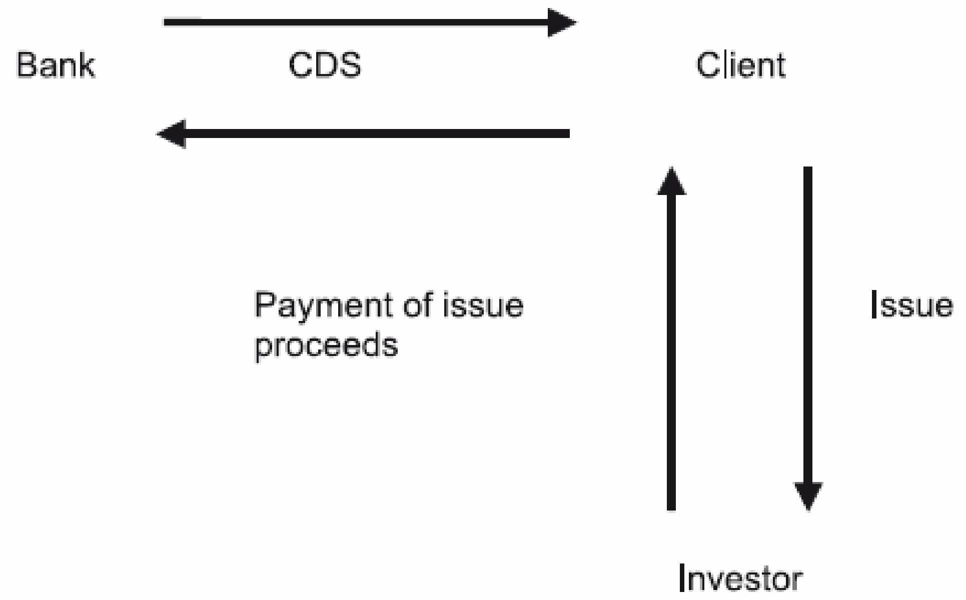
Credit derivatives



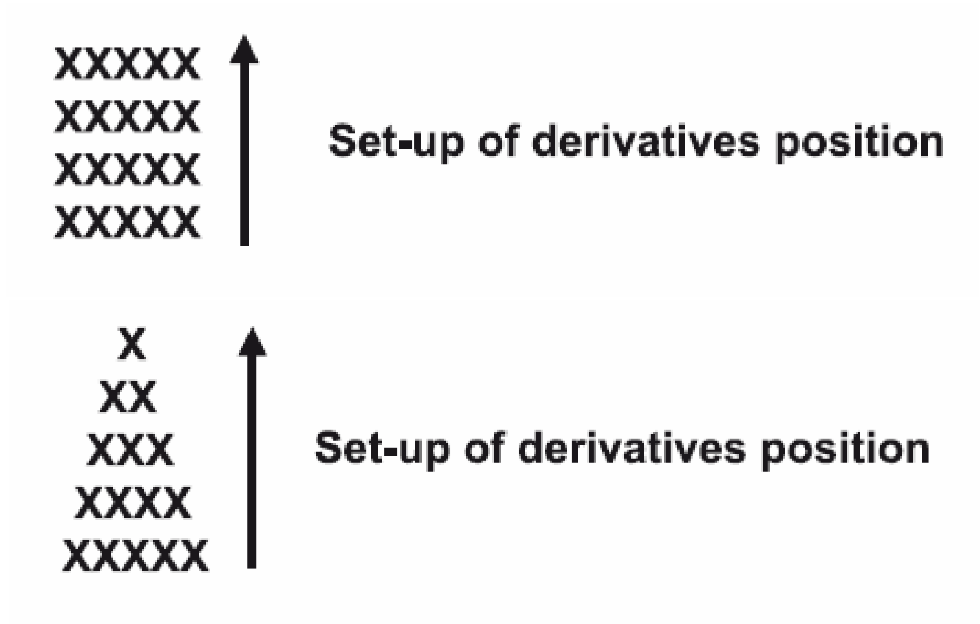
Credit derivatives



CLN



Set-up of derivatives position



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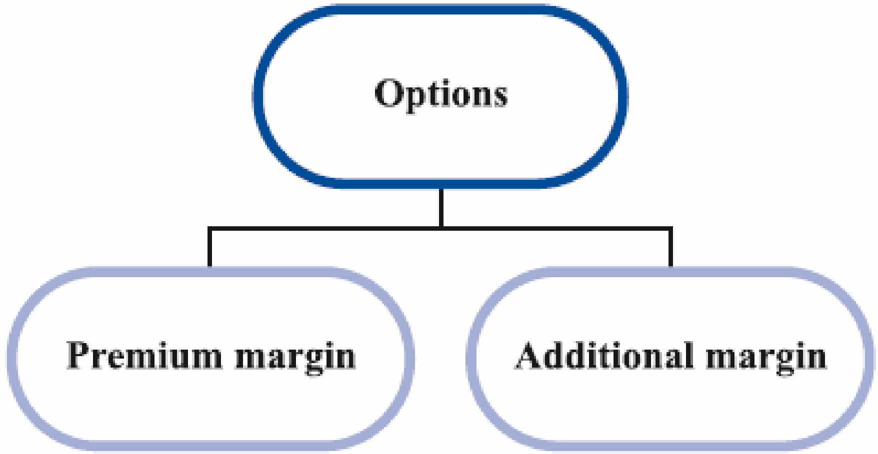
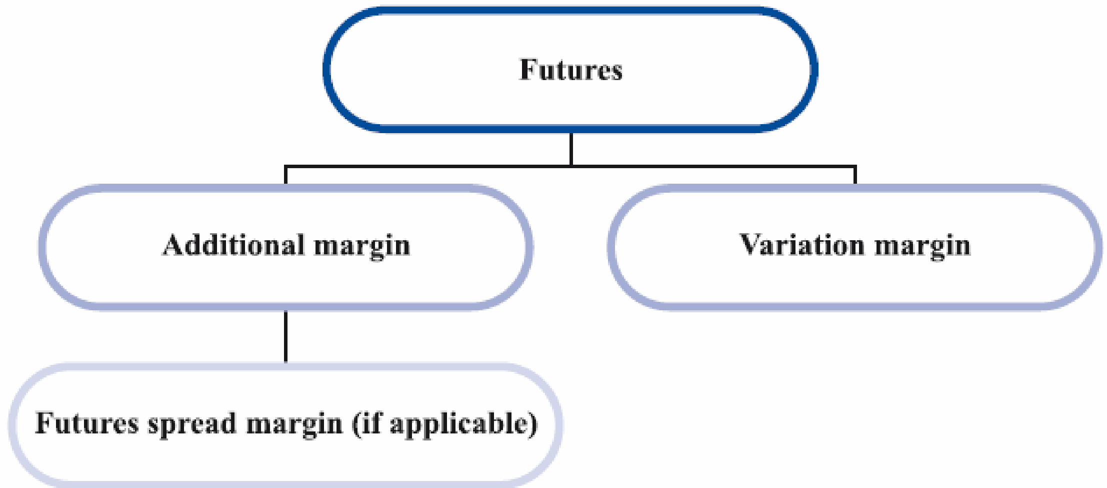
Margin

Options on stocks, ETF, and indices

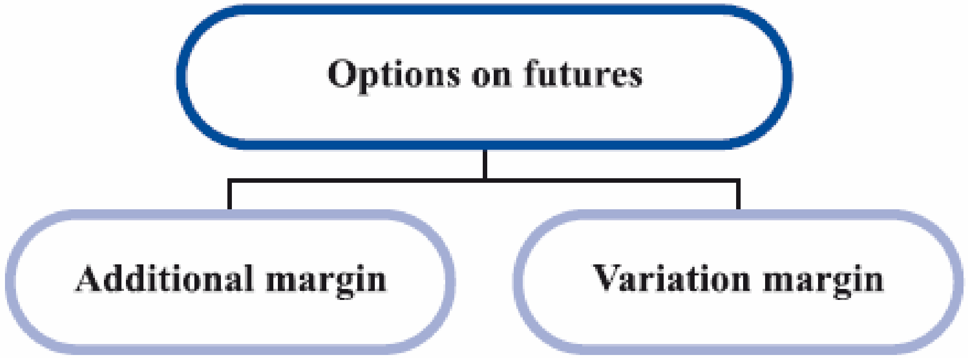


Futures



Margin

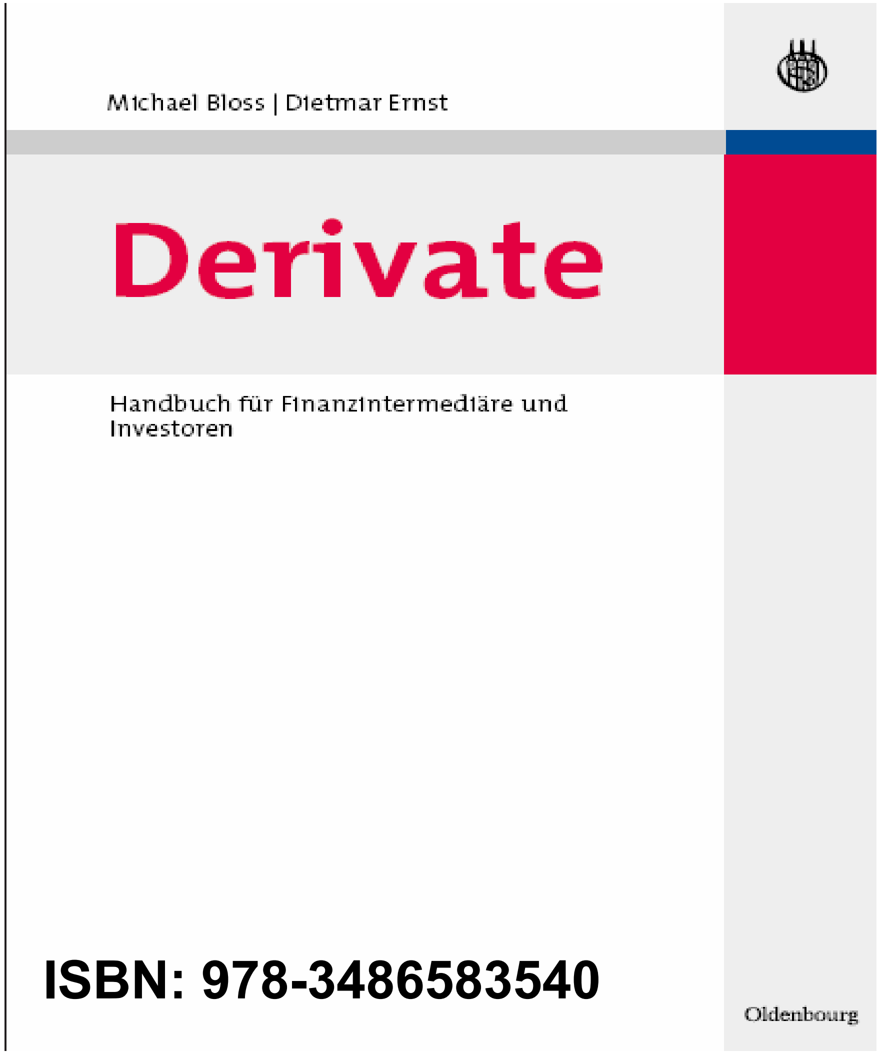
Options on futures



Short option adjustment

Short option adjustment =
Margin parameter x out-of-the-money minimum + daily settlement price

Books



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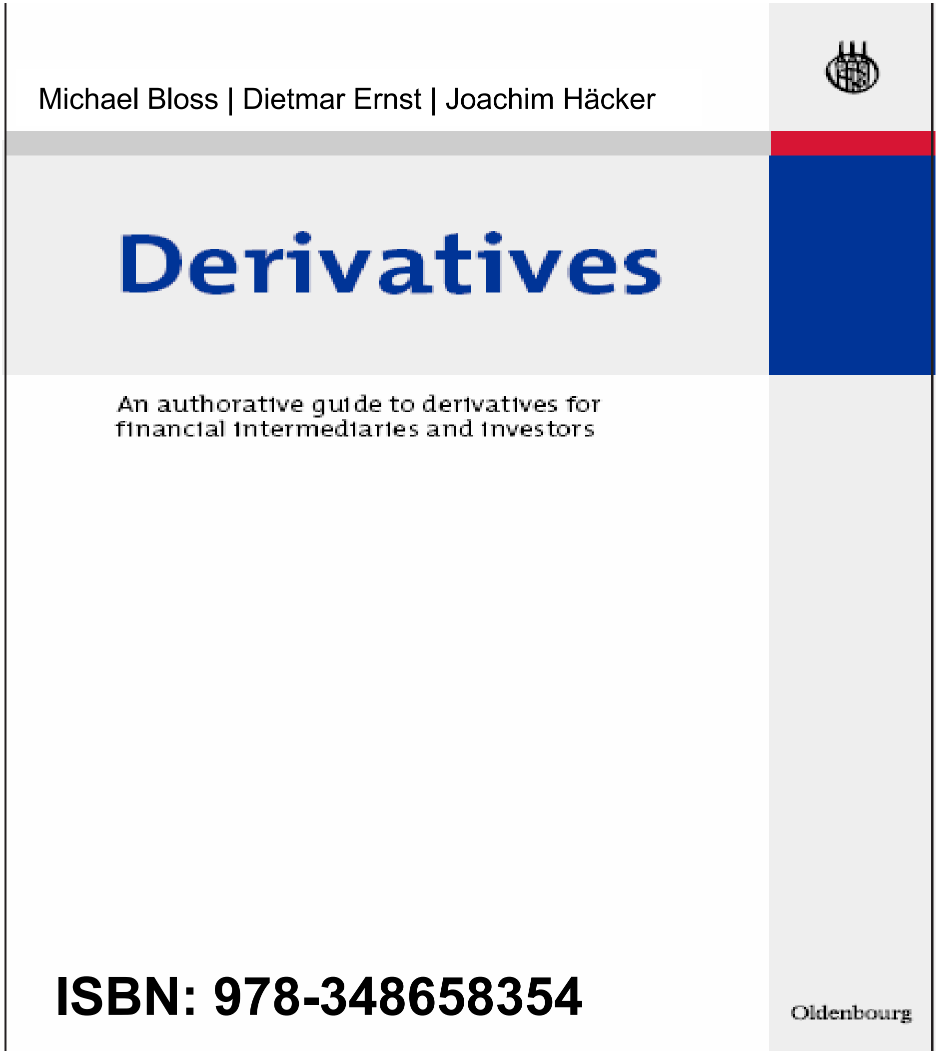

ISBN: 978-348658354

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