Module 7: Derivative Securities

(BUSFIN 4221 - Investments)

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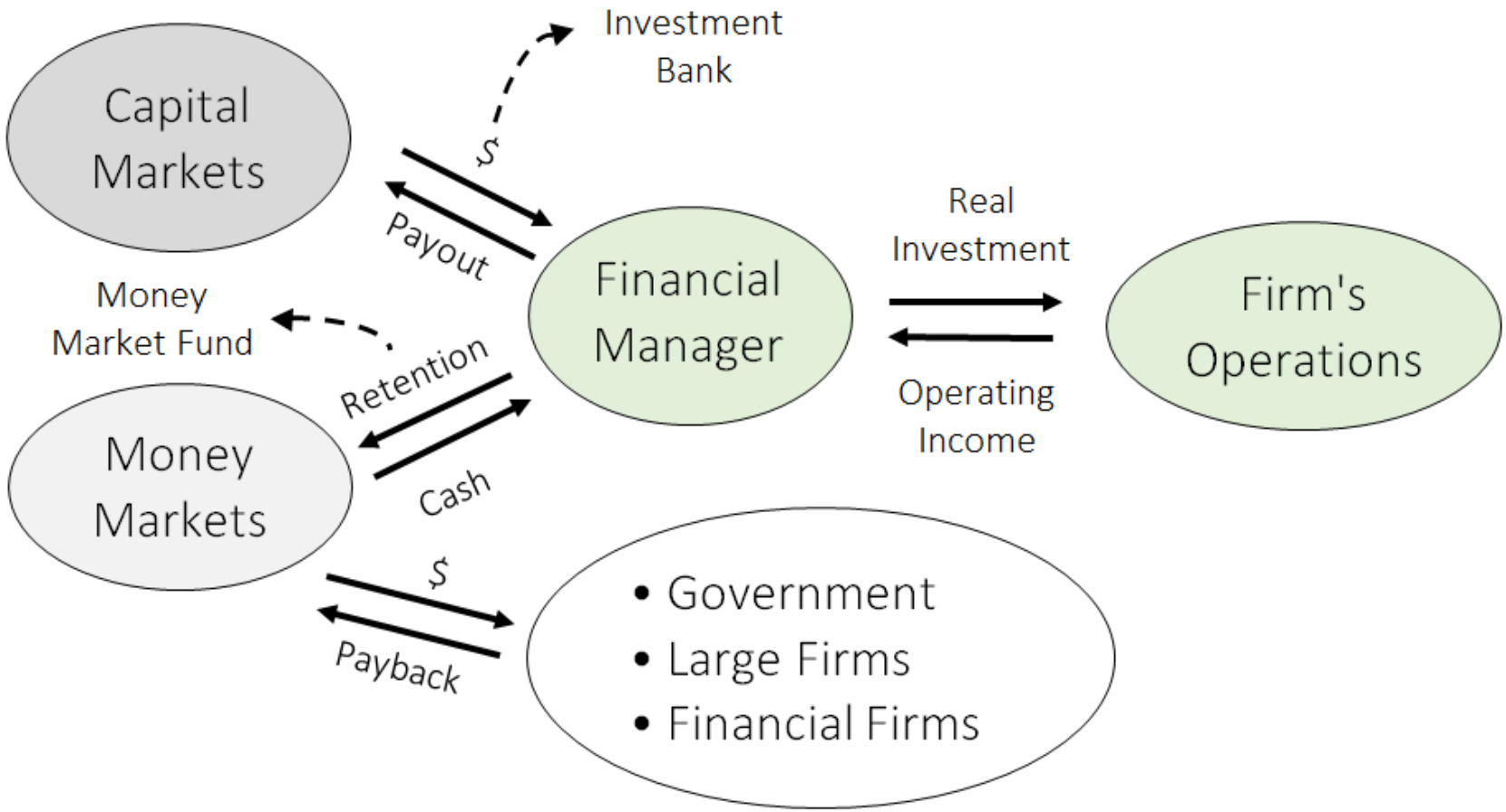
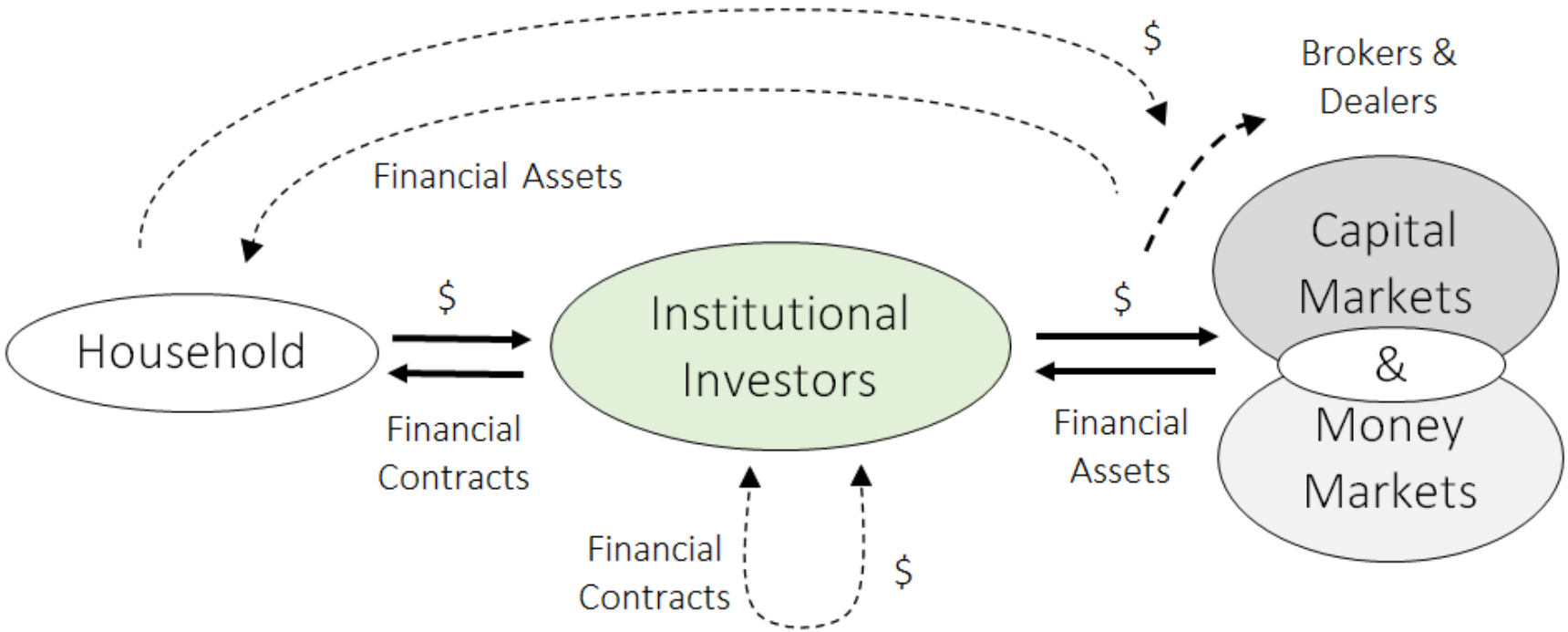
Fall 2016

Outline

Module 1 - The Demand for Capital



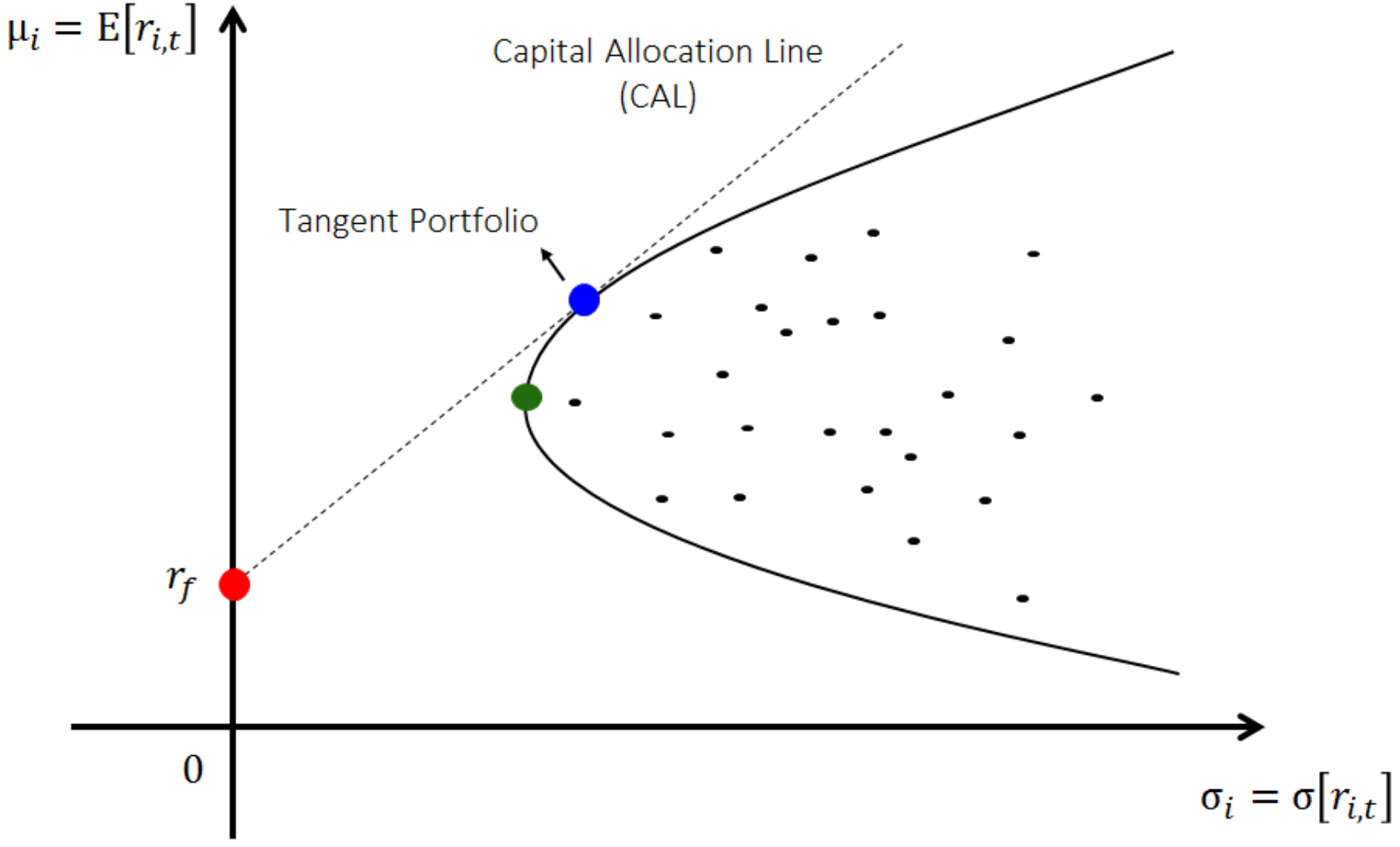
Module 1 - The Supply of Capital



Module 1 - Investment Principle

$$PV_t = \sum_{h=1}^{\infty} \frac{\mathbb{E}_t \left[CF_{t+h} \right]}{\left(1 + dr_{t,h} \right)^h}$$

Module 2 - Portfolio Theory



Module 3 - Factor Models

$$\mathbb{E}[r_i] = r_f + \beta_i \cdot (\mathbb{E}[r_M] - r_f)$$

$$+ \beta_{i,A} \cdot \mathbb{E}[r_A - r_a]$$

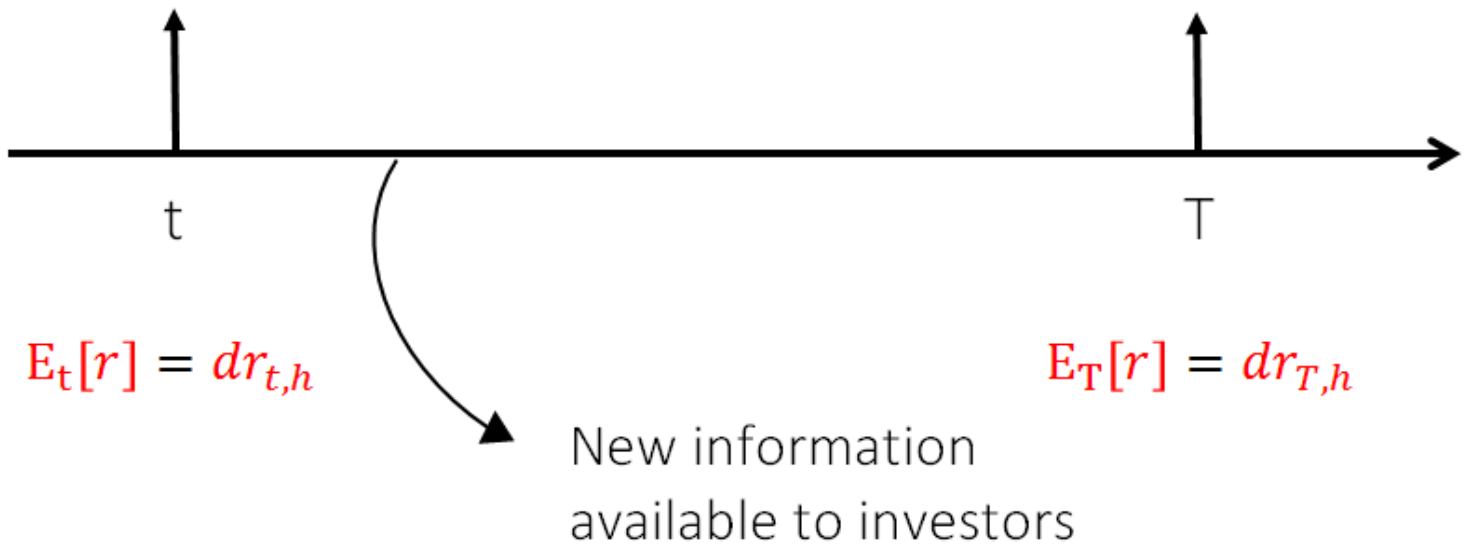
$$+ \beta_{i,B} \cdot \mathbb{E}[r_B - r_b]$$

$$+ \ldots$$

Module 4: Market Efficiency

$$P_t = \sum_{h=1}^{\infty} \frac{E_t[CF_{t+h}]}{(1 + E_t[r])^h}$$

$$P_T = \sum_{h=1}^{\infty} \frac{E_T[CF_{T+h}]}{(1 + E_T[r])^h}$$



Module 5: Debt Securities

$$P_t = \frac{c \cdot F}{(1+y)^1} + \frac{c \cdot F}{(1+y)^2} + \ldots + \frac{c \cdot F + F}{(1+y)^H}$$

Module 6: Equity Securities

$$P_t = \frac{\widehat{D}_{t+1}}{(1+dr)^1} + \frac{\widehat{D}_{t+2}}{(1+dr)^2} + \frac{\widehat{D}_{t+3}}{(1+dr)^3} + \ldots$$

where $\widehat{D}_{t+h} = D_t \cdot (1+\widehat{g})^h$

Outline

This Module: Derivative Securities

What is a derivative?

- Derivative: "Contract in which the payout depends on (or derives from) the value of other underlying asset/variable"
- John is a farmer. This last May he spent 100 Million dollars to plant wheat, which he is planning on selling on September.
- His profits are uncertain since he does not know the wheat price in September
- Price changes represent a risk to John, which he can "hedge against" by entering a contract in which he agrees to sell his wheat for 5 cents per busher (in September) to somebody else.
- If September price is higher than 5 cents, John will get a profit lower than he could (since he will be obligated to sell it for 5 cents). However, he is insured against price decreases.
- The derivative payout depends on the September wheat price.

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Types of Derivatives and where they Trade

- "The range of derivatives contracts is limited only by the imagination of man (or sometimes, so it seems, madmen)." (Warren Buffett, 2002)
- The most common types of derivatives are:
  - Forwards
  - Futures
  - Swaps
  - Options
- Forward and Swaps are traded over-the-counter (OTC).
  - A telephone and computer-linked network of dealers
  - Financial institutions often act as market makers
- Futures are traded in organized exchanges
- Options are traded both in exchanges and in the OTC market

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Pros and Cons of the OTC Market

- Pros of OTC market:
  - Contracts can be tailor-made to meet specific needs
  - You can create new derivatives by negotiating with Dealers
- Cons of OTC market:
  - Liquidity can dry out quickly in OTC markets
  - There is counterparty risk
  - Domino effect due to interconnected balance sheets (produces systemic risk)
- Ex: AIG was "too interconnected to fail".
  - Regulatory response was to create a "clearinghouse for some derivatives"
  - CDS are now cleared by intercontinental exchange

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  - Formed by the merger of Chicago Mercantile Exchange (CME) and Chicago Board of Trade (CBOT) in 2007
  - Largest futures exchange in the world
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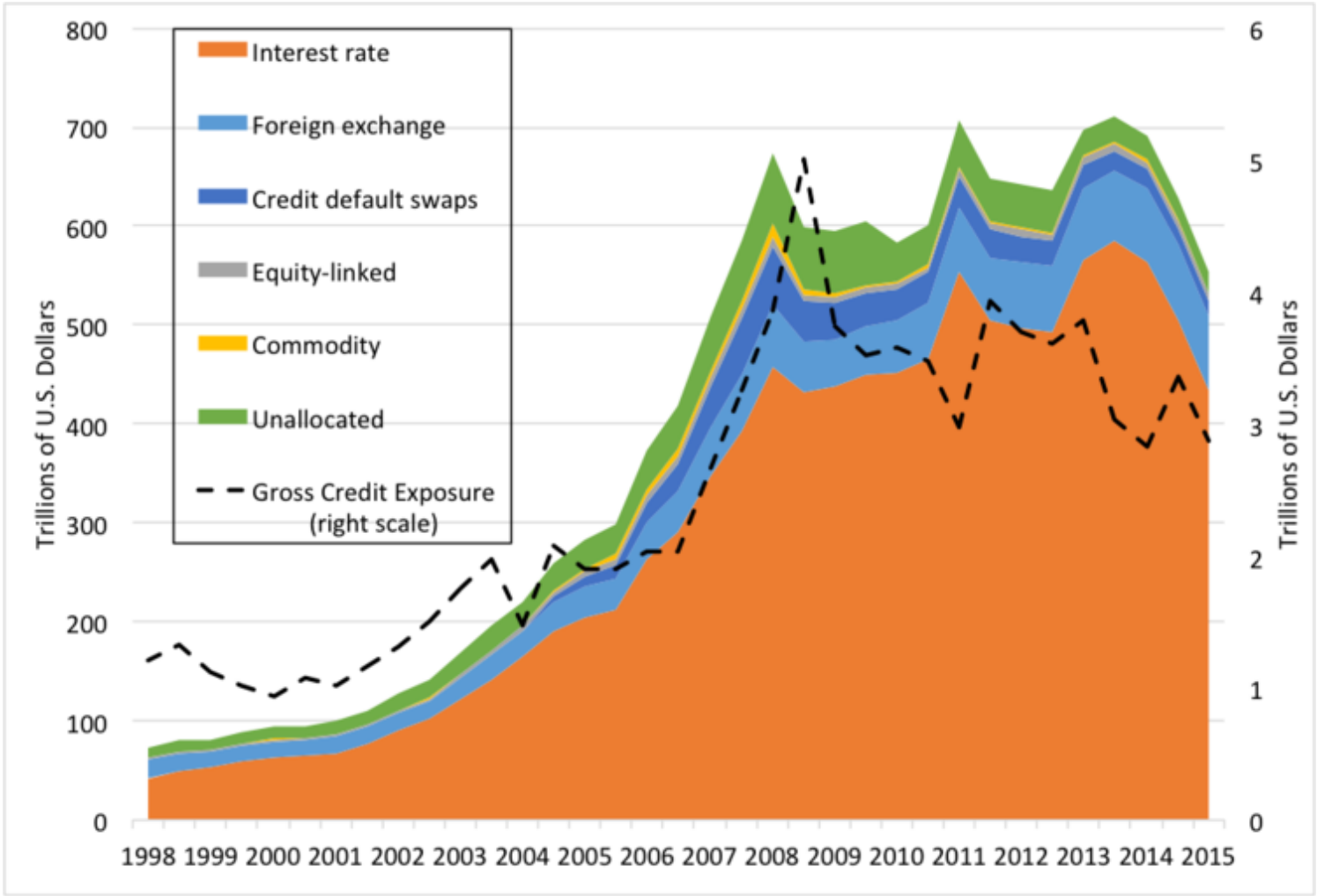
CME Trading Floor

The size of OTC Derivatives Market*



Source: Money, Banking and Financial Markets

For each of these contracts, answer if it can be considered a derivative contract (Yes) or not (No):

- A contract in which I agree to pay you 1 Million dollars if Hillary Clinton wins the election and you pay me 1 Million dollars if Donald Trump wins
- A contract in which I agree to pay you \$1,000 times the average temperature in the next summer (in Ohio)
- A contract in which you given me 1 Million dollars today and I agree to pay you 1.1 Million dollars in one year

a) (i) Yes; (ii) Yes; (iii) Yes

b) (i) No; (ii) No; (iii) No

c) (i) Yes; (ii) No; (iii) No

d) (i) Yes; (ii) Yes; (iii) No

e) (i) No; (ii) No; (iii) Yes

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d) (i) Yes; (ii) Yes; (iii) No

e) (i) No; (ii) No; (iii) Yes

Outline

This Section: Forward and Future Contracts

- What are future contracts?
- What are forward contracts?
- What are the similarities and differences between them?
- How can forward and future contracts be used to hedge?
- How can forward and future contracts be used to speculate?
- How to value forward and future contracts?

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Walmart Example: The Problem

- Walmart has a large subsidiary in Brazil.
- Part of the profits are reinvested in Brazil, but part of it comes to the parent in the United States.
- Since its profits in Brazil are in BRL, they need to be converted to USD before the parent company can use it.
- As such, the exchange rate is an important risk factor for Walmart. They can use currency futures to hedge against it.
- Suppose Walmart predicts that about 1 Billion BRL of its 2017 profits (available in December of 2017) will be used in the parent company
- Today, the exchange rate is 0.32 USD per BRL and, thus, the 1 Billion BRL translates to 0.32 Billion USD. However, its USD value in December of 2017 is uncertain.

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Walmart Example: The Problem

- Walmart has a large subsidiary in Brazil.
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Walmart Example: The Risk*

Walmart Example: The Hedge

- The exchange rate can move a lot over the period of 1 year
- A decrease of 0.1 in the exchange rate is equivalent to 100 Million USD less in profits for the parent company to keep
- Walmart can enter an agreement to exchange BRL for USD in December of 2017 at a prespecified exchange rate.
- Such agreement is called a foreign currency future and Walmart would take a long position on it (i.e., it would agree today to buy USD in December of 2017)
- The December 2017 futures contract is at 0.29 (as of today) $\Longrightarrow$ 0.29 Billion USD guaranteed for the parent company in December 2017 (the cash flow is "hedged")
- The current exchange rate was $0.32 > 0.29$. Why? We need to understand "future contracts" to answer this

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Future Contracts: Categories

- There are four broad categories of "underlying asset/security":
  - Agricultural commodities (e.g., wheat)
  - Metals and Minerals (e.g., gold)
  - Foreign Currencies (e.g., $\frac{\text{USD}}{\text{BRL}}$)
  - Financials (ex: fixed income securities and stock indexes)
- Other smaller categories exist (elections, weather, ...)
- Futures are exchange traded and, thus, the contracts are very standardized and specify all necessary details regarding the underlying asset being delivered
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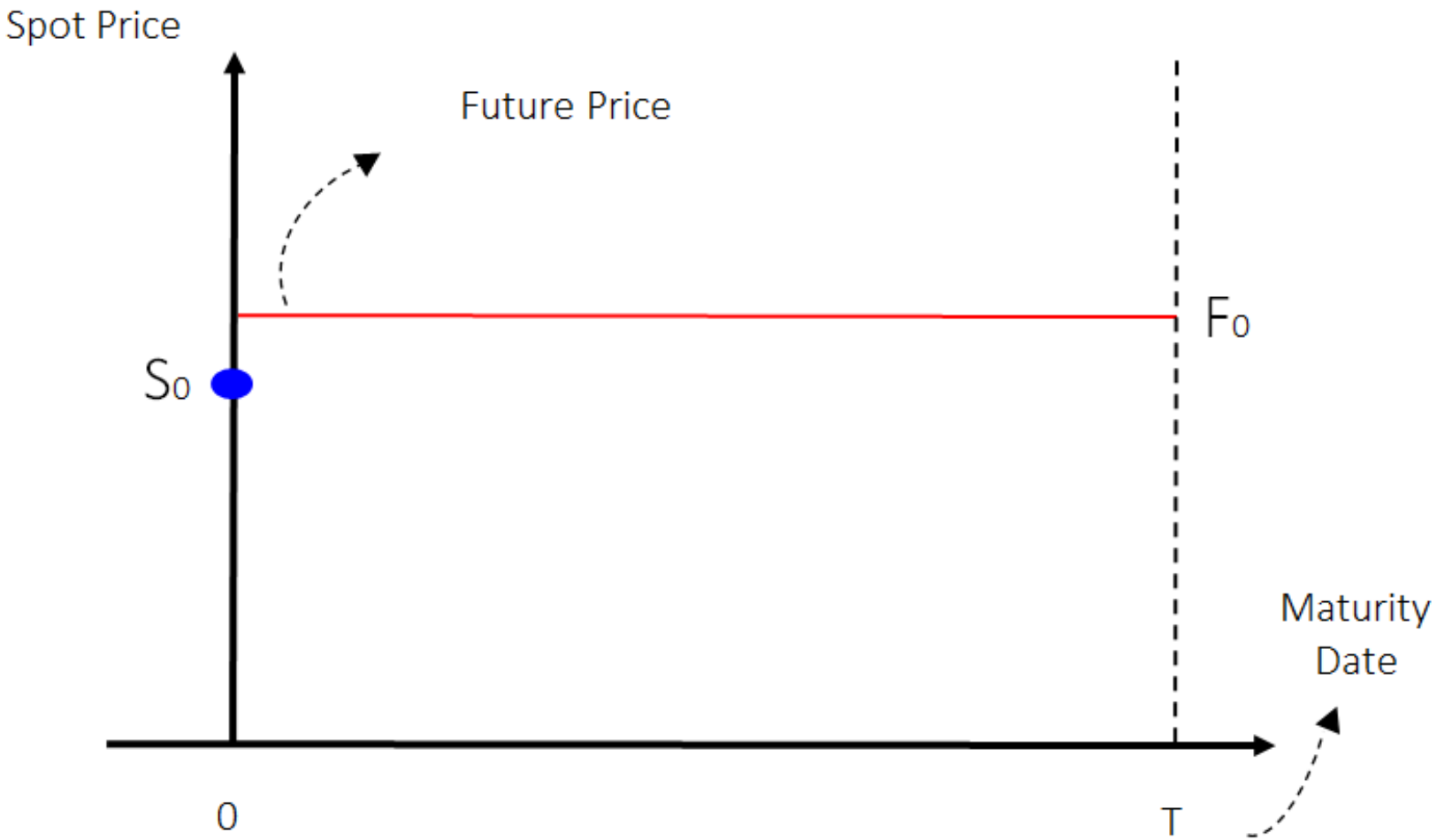

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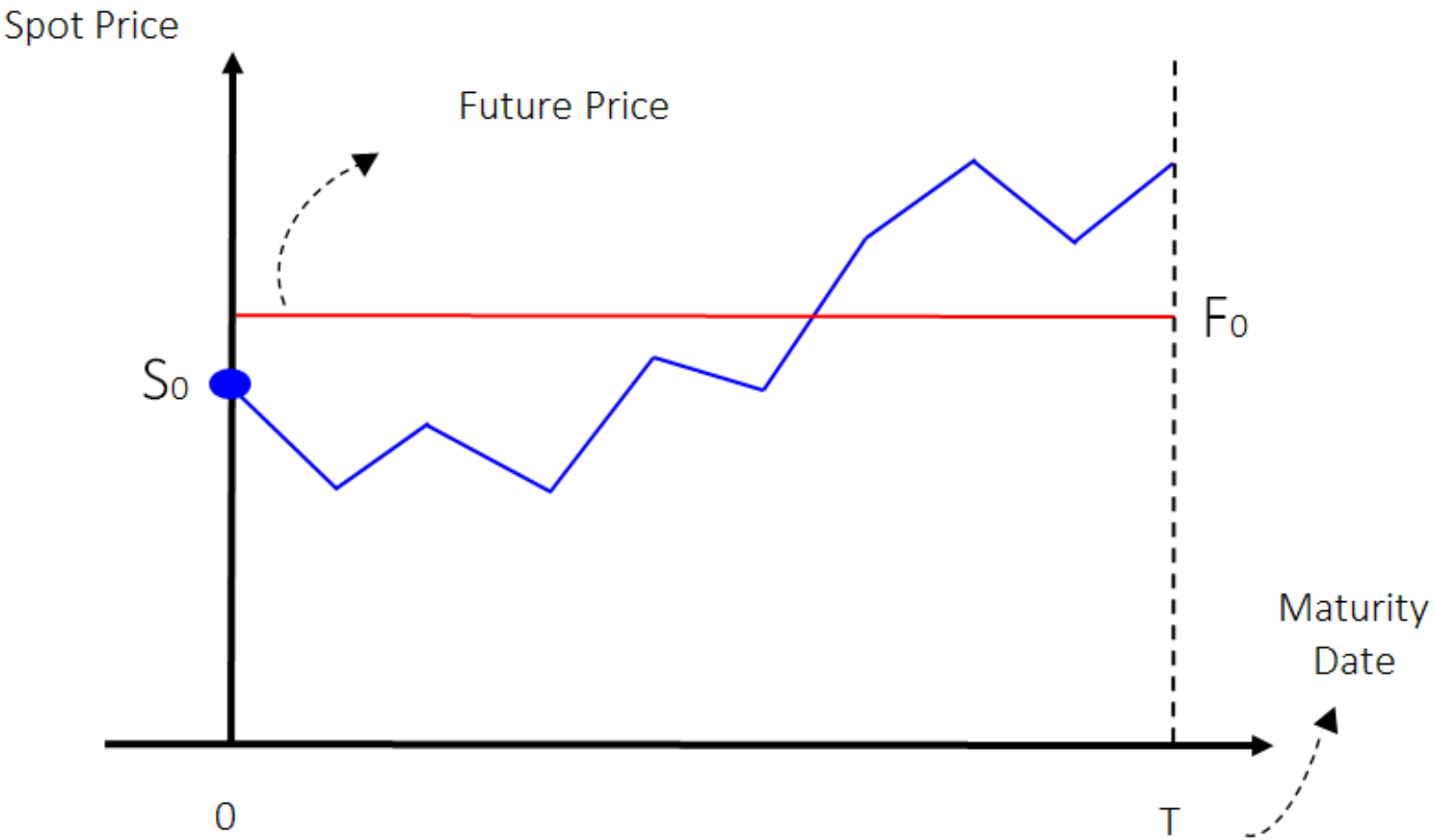

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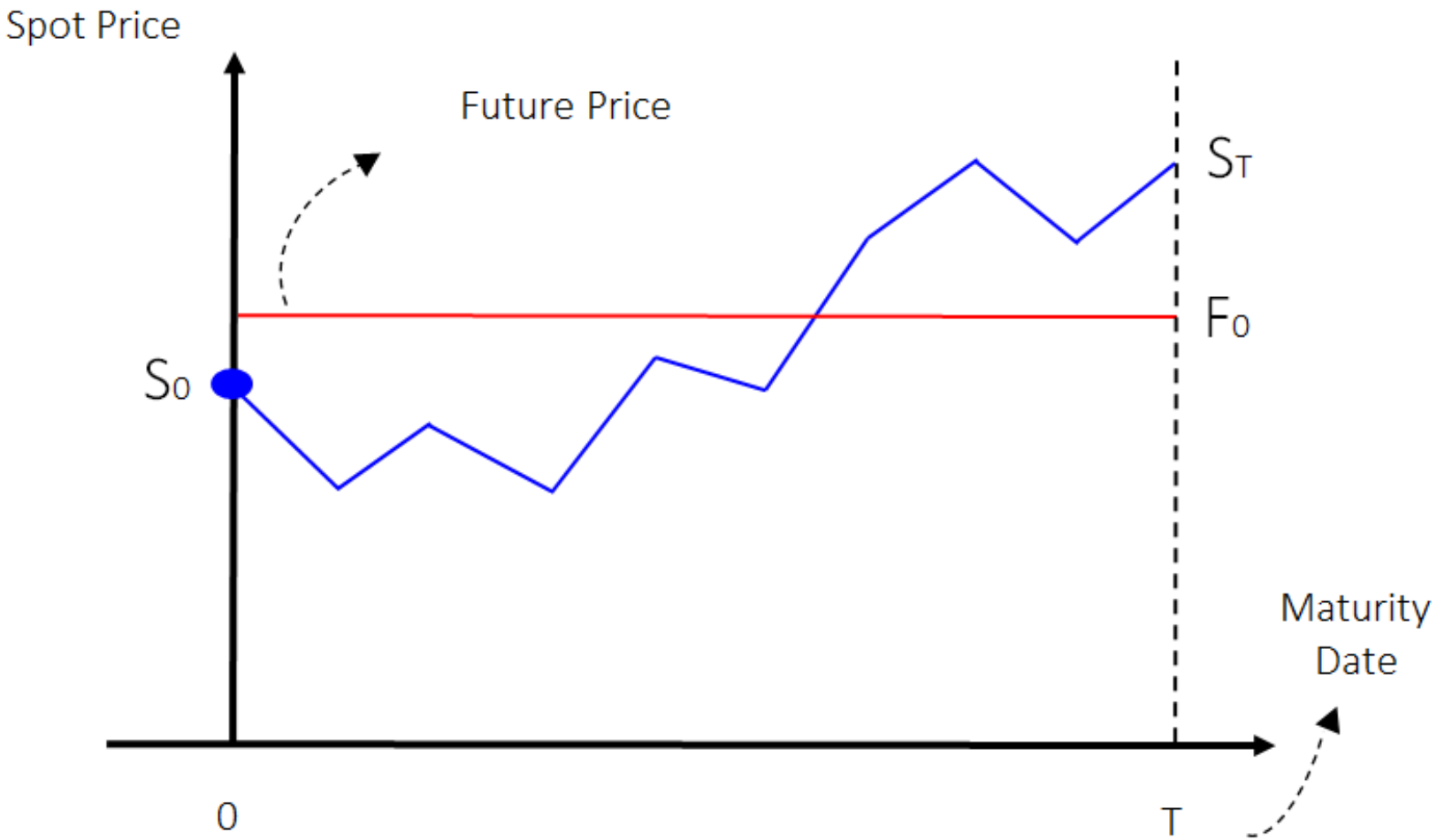

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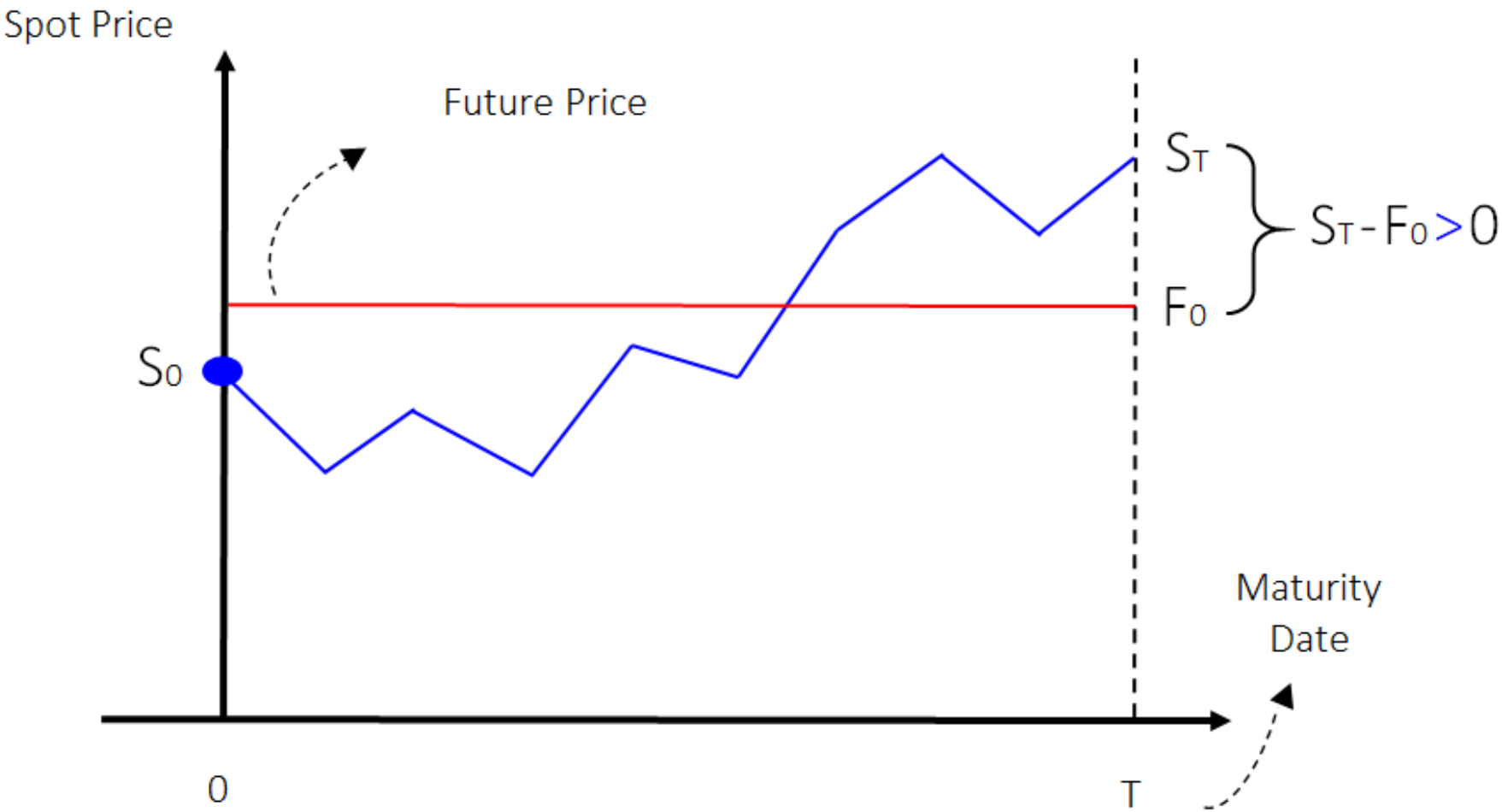

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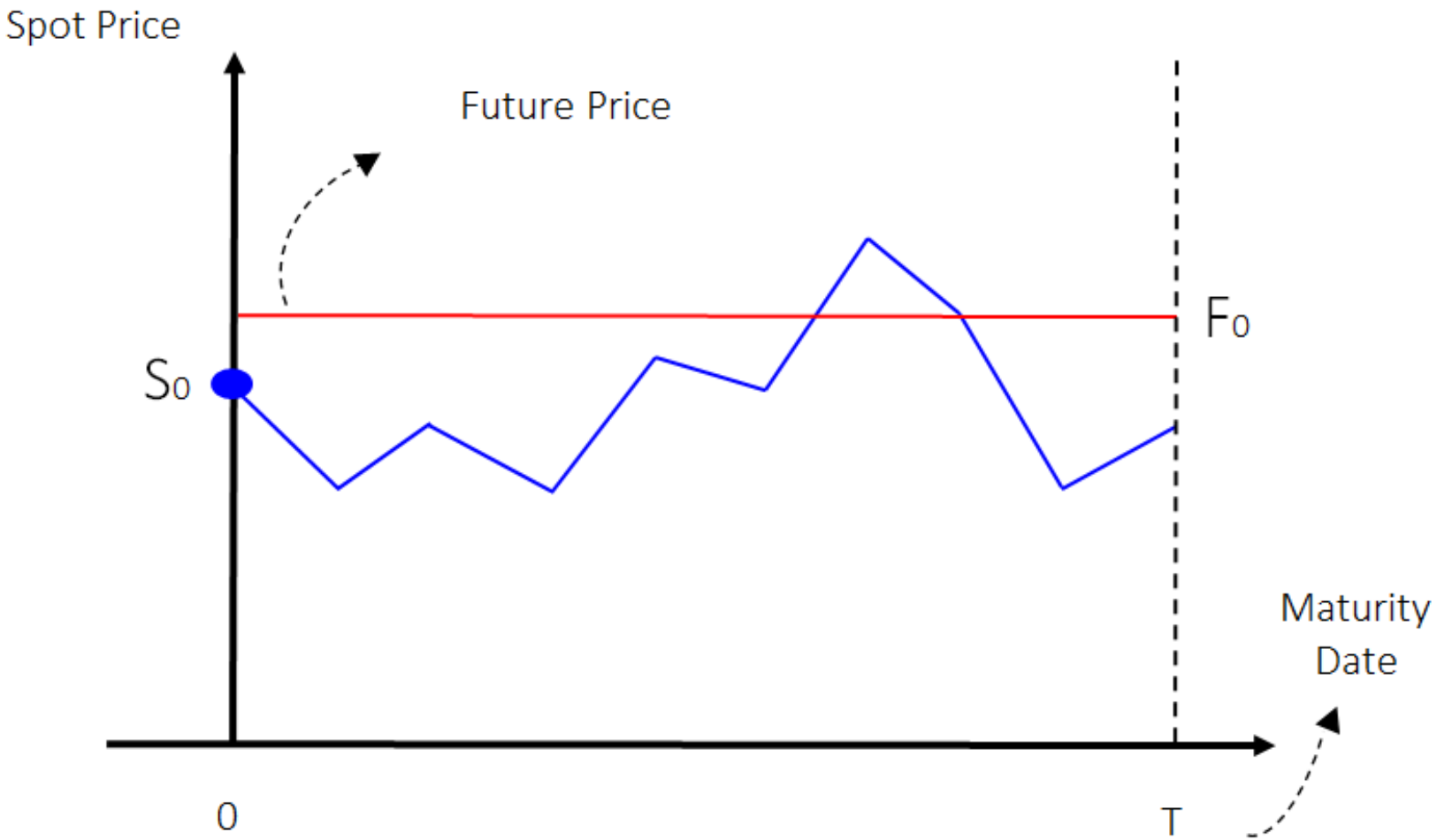

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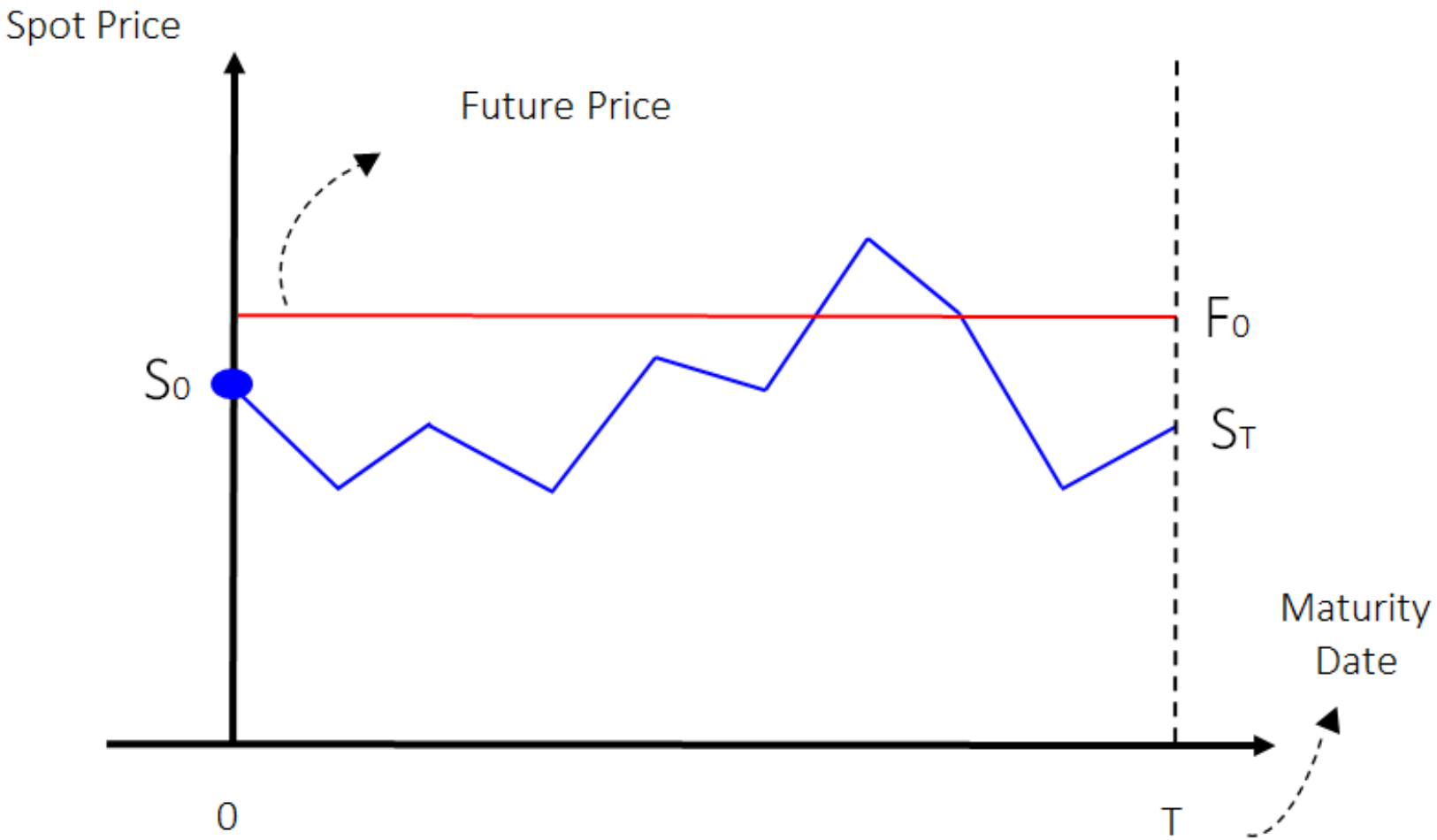

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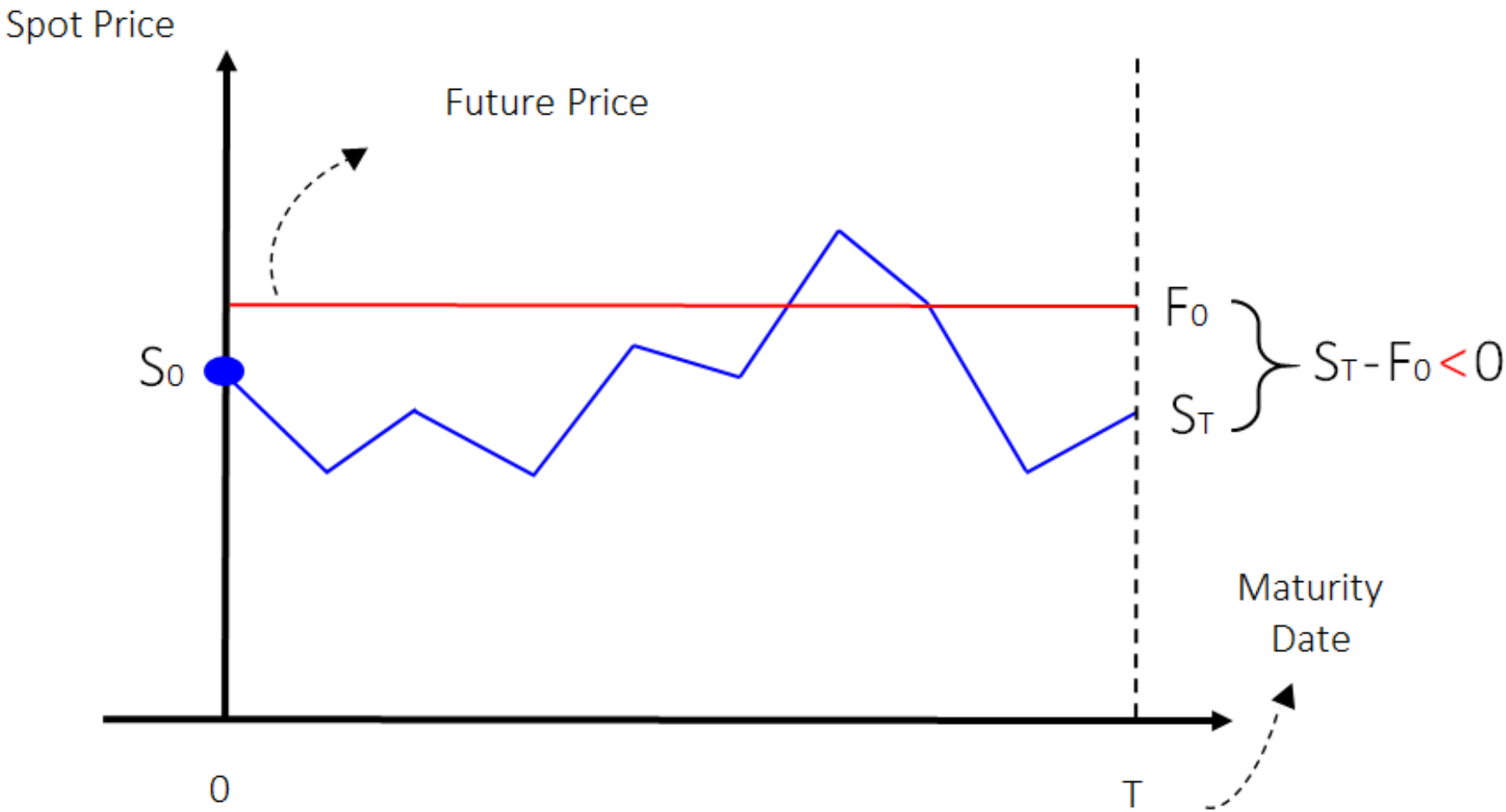

Future Contracts: Closing Positions

- Future contracts specify an underlying asset to be delivered at maturity (e.g., corn)
- Most trades do not lead to physical delivery. How come?
- Recall that the payoff of a long position is $S_T - F_0$ while the payoff of a short position is $F_0 - S_T$.
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- At time t, F_t is known and you are effectively closing your position (you know what your payoff will be at time T)
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- Recall that there is a clearing house to make sure there are no defaults (no counterparty risk). How come?
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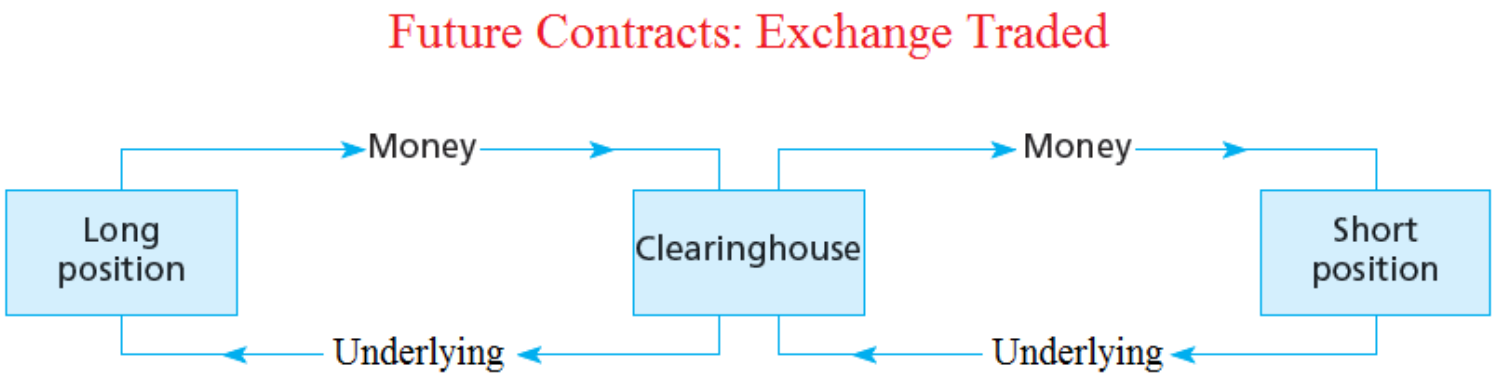

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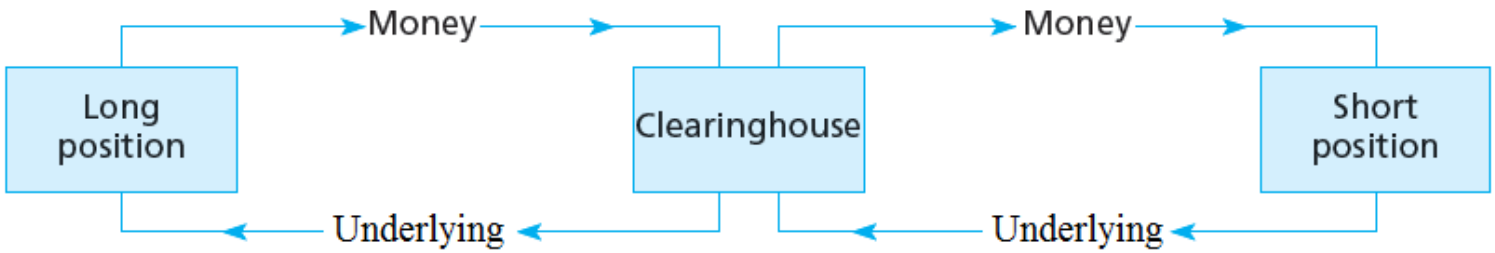
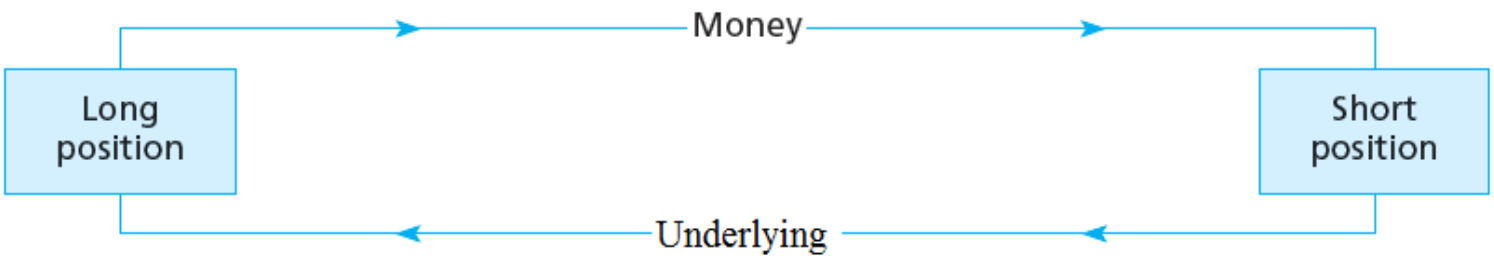
Future Contracts: Exchange Traded



Forward Contracts: Traded OTC



Valuation: No Arbitrage Pricing

Strategy	Initial Cost of Position	Cash Flow at time T
Buy Underlying Asset	S_0	S_T
Enter Long Position	0	$S_T - F_0$
Invest $F_0/(1+r_f)^T$ in TBills	$F_0/(1+r_f)^T$	F_0
Position 1 + Position 2 =	$F_0/(1+r_f)^T$	S_T

- Since the two strategies have the same cash flow at time T, they must have the same price (initial cost of position).
- If this did not hold, one of the two strategies would be "cheap" and we would able to profit from it (it is what we call an arbitrage opportunity).

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Invest $F_0/(1+r_f)^T$ in TBills	$F_0/(1+r_f)^T$	F_0
Position 1 + Position 2 =	$F_0/(1+r_f)^T$	S_T

- Since the two strategies have the same cash flow at time T, they must have the same price (initial cost of position):

$$F_0 = S_0 \cdot (1 + r_f)^T$$

- If this did not hold, one of the two strategies would be "cheap" and we would able to profit from it (there would be an arbitrage opportunity).

Valuation: No Arbitrage Pricing

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$$F_0 = S_0 \cdot (1 + r_f)^T$$

- The derivation in the previous slide assumes that:
  - the underlying asset has no cash flows between 0 and T
  - The term structure is flat (so that the risk-free rate, r_f, is the yield for all maturities)
- Relaxing these assumptions, we can use an approach similar to the previous slide to find:

$$F_0 = (S_0 - PV_{CF}) \cdot (1 + y)^T$$

- PV_{CF} is the present value of all cash flows associated with the underlying asset between 0 and T
- y represents the bond yield for the respective maturity

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Suppose you form a portfolio with the following positions:

- A short position on 1 share of Microsoft (currently valued at $60)
- A future contract to buy 1 share of Microsoft one year from now at price $70
- A position in 1 year zero-coupon treasuries with face value $70

If you do not change your positions, what is the value of your total portfolio one year from now?

a) You cannot determine (today) the value your portfolio will have one year from now since it will depend on future prices

b) Your portfolio will be worth zero

c) Your portfolio will be worth $60

d) Your portfolio will be worth $70

e) Your portfolio will be worth $70 minus whatever Microsoft stock price is at that point

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Outline

This Section: Swap Contracts

- What are Swap contracts?
  - Agreements to swap one cash flow for another at multiple dates
  - They are effectively multiperiod extensions of forward contracts
- Why are they useful?
  - They can be used for risk management purposes. They allow firms (financial and non-financial) to effectively hedge recurrent risks
- Why they can induce Systemic Risk?
  - OTC trading induces different firms to be exposed to the same counterparty risks
- How can they be priced?
  - Using the "No Arbitrage Principle"

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Hedge Fund vs Verizon Example: The "Plain Vanilla" Swap

- The Interest rate (LIBOR rate) is currently at 1.5% and a Hedge Fund thinks it will decrease over the next 5 years.
- Verizon has a 5 years debt contract (notional of $100 Million) in which it pays annual interest of 4% + LIBOR.
- While the Hedge Fund wants to bet on the LIBOR rate decrease, Verizon wants to get rid of its floating interest rate
- They can enter a $100 Million contract (called an "Interest Rate Swap") in which, over the next 5 years, Verizon pays (annually) a fixed rate of 1.5% and the Hedge Fund pays (annually) whatever the LIBOR rate is at that point in time.
- The Hedge Fund makes money if the LIBOR rate decreases and Verizon transformed the interest rate of its debt contract into a fixed rate: $4\% + 1.5\% = 5.5\%$. Both are happy!

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Hedge Fund vs Verizon Example: Notional = $100 Million

Year	LIBOR	Hedge Fund Obligation	Verizon Obligation	Net Cash Flow Paid
0	1.5%	$0	$0	$0
1	1.8%	$1.8 Million	$1.5 Million	$0.3 Million
2	1.6%	$1.6 Million	$1.5 Million	$0.1 Million
3	1.5%	$1.5 Million	$1.5 Million	$0.0 Million
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- The fixed rate on the Swap contract is set at the beginning (in such a way that both parties agree that no money exchange is needed at that point). It does not need to be 1.5% (as we will see later).
- At each year, only the net cash flow is exchanged. For instance, in Year 4, only Verizon pays $0.2 Million (decreases counterparty risk)
- For Verizon, the losses/gains are offset by its debt payments (not shown in the table). As such, it is hedged

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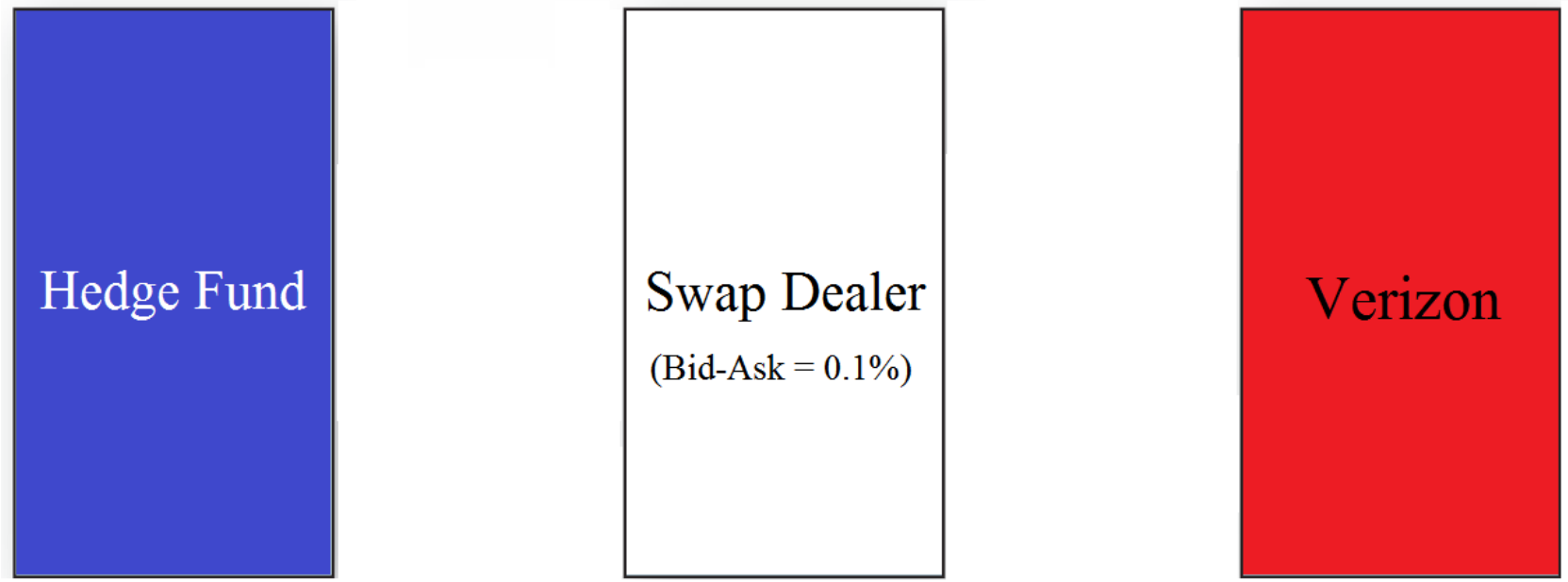
The OTC Trading Mechanism and Systemic Risk*



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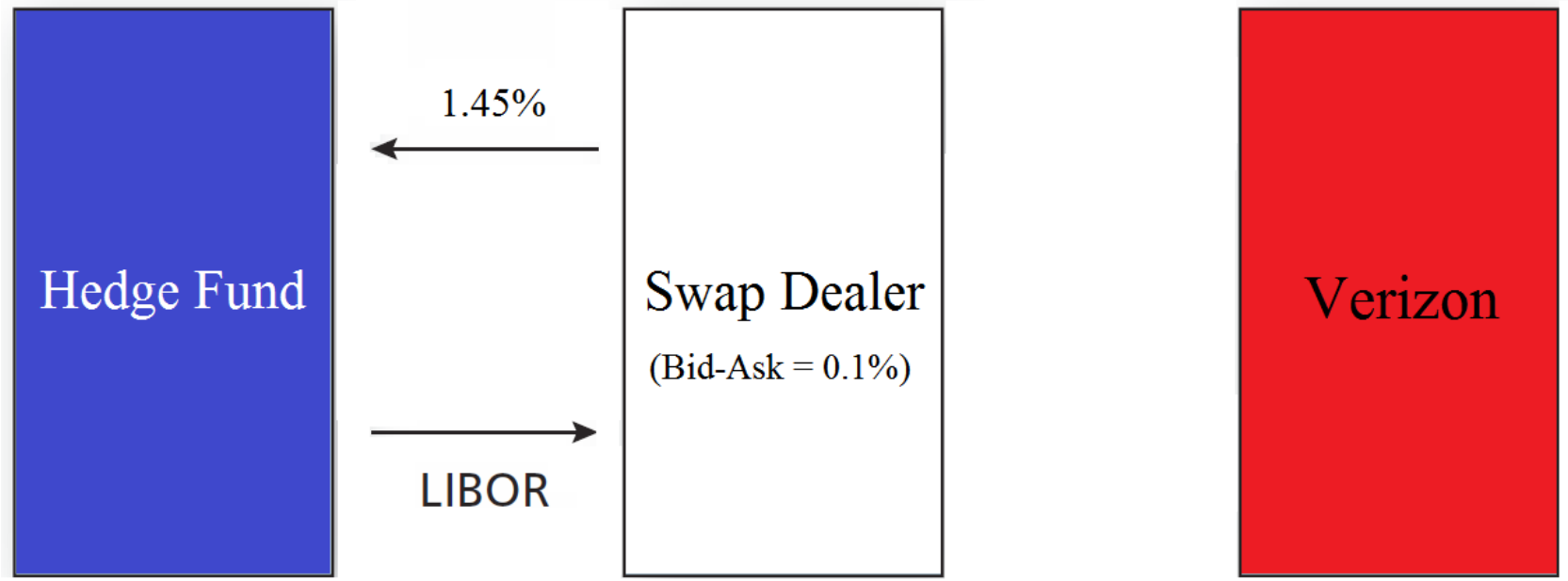

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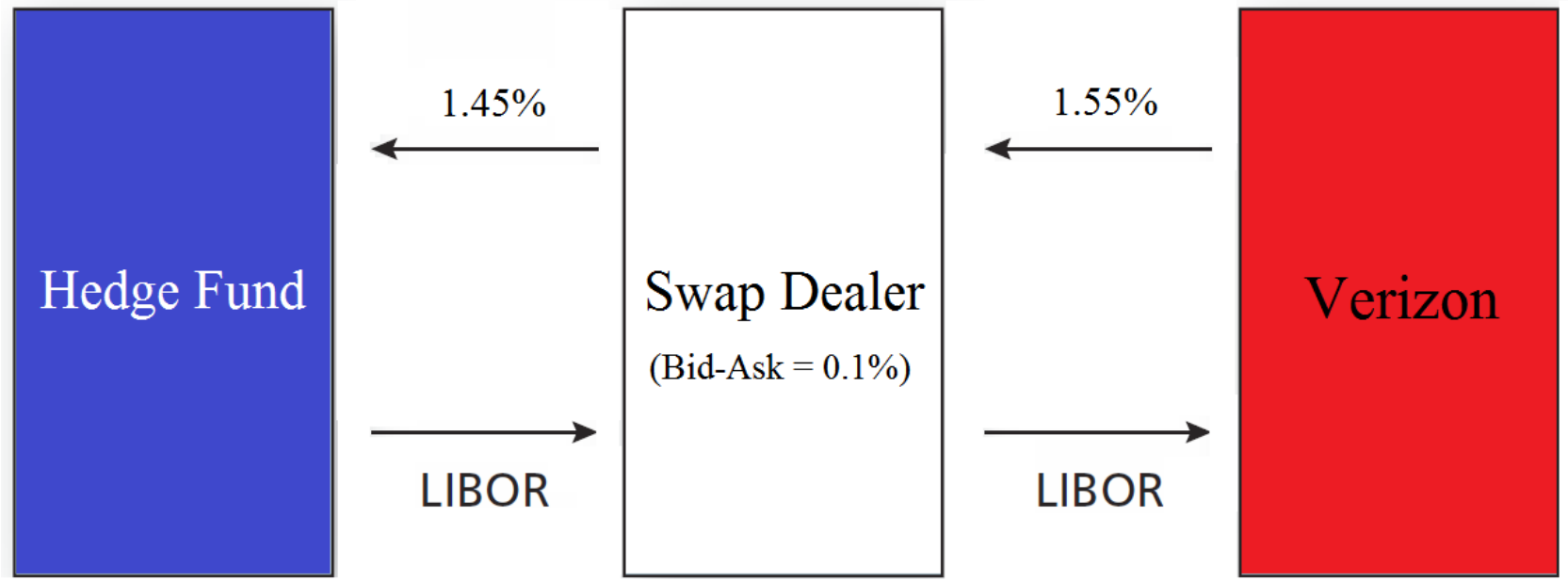

Valuation: No Arbitrage Pricing

- We can use the Fundamental Valuation Equation to price Swaps. However, it becomes complicated. Instead, we approach it the same way we do it with Futures/Forwards (No Arbitrage Pricing Principle).
- One way is to view a Swap as a basked of Forward contracts and price it based on the Forward pricing.
- Another way is to think directly about the underlying assets of the Swap contract and price it accordingly. We will focus on this approach since is the simplest (obviously, all three approaches lead to the same final pricing equation).
- In our simple example, the underlying assets are a Floating Rate Bond and a Fixed Rate Bond. Let's take the Hedge Fund perspective (the company paying the floating rate). Since it is a zero sum game, the other is negative of that.

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- If the Hedge Fund receives the fixed rate and pays the floating rate, it effectively has a long position on the fixed rate bond and a short position on the floating rate bond:

$$P_{swap} = P_{fix} - P_{float}$$

- If we can value the bonds, we can value the Swap.
- The floating rate bond trades at face value on coupon days. This is because its "coupon rate" is basically being adjusted to match the yield to maturity every time it pays coupon. Hence, it trades at par: $P_{float} = \text{Notional Value} = \text{N}$
- The fixed rate bond is a regular bond and, thus:

$$P_{swap} = \underbrace{\left[\frac{\text{N}}{(1+y)^H} + \sum_{h=1}^{H} \frac{(\text{fixed rate}) \cdot \text{N}}{(1+y)^h}\right]}_{P_{fix}} - \underbrace{\text{N}}_{P_{float}}$$

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- At date 0 (when the contract is issued), the fixed rate is set such that $P_{swap} = 0$. This can only happen when fixed rate equals the yield to maturity at that point, y_0 (so that the fixed rate bond is also at par). Thus: $\text{fixed rate} = y_0$
- As a result:
  - If $y > y_0 \Longrightarrow P_{fix} < P_{float} \Longrightarrow P_{swap} < 0$
  - If $y < y_0 \Longrightarrow P_{fix} > P_{float} \Longrightarrow P_{swap} > 0$
- The Hedge Fund position is similar to a long position on the Bond issued at par in the sense that he makes money if yields decrease. However, the Swap allows for implicit leverage.

Valuation: No Arbitrage Pricing*

$$P_{swap} = \underbrace{\left[\frac{\mathrm{N}}{(1+y)^H} + \sum_{h=1}^{H} \frac{(\text{fixed rate}) \cdot \mathrm{N}}{(1+y)^h}\right]}_{P_{fix}} - \underbrace{\mathrm{N}}_{P_{float}}$$

- At date 0 (when the contract is issued), the fixed rate is set such that $P_{swap} = 0$. This can only happen when fixed rate equals the yield to maturity at that point, y_0 (so that the fixed rate bond is also at par). Thus: $\text{fixed rate} = y_0$
- As a result:
  - If $y > y_0$ $\Rightarrow$ $P_{fix} < P_{float}$ $\Rightarrow$ $P_{swap} < 0$
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Suppose at time $t = 0$ you entered a "plain vanilla" interest rate swap with notional value of \$100 Million. You agreed to pay a fixed rate of 4% and your counterparty agreed to pay you the LIBOR rate (once per year over the next 5 years). Which of the following is false regarding this situation?

a) If counterparty risk is zero, the 5-year yield to maturity of zero-coupon treasuries was 4% at $t = 0$

b) If interest rates go down, your position in this Swap contract will become less valuable

c) You are exposed to counterparty risk. The risk is higher than if you had bought (with the same counterparty) a 5-year floating rate bond paying LIBOR once per year

d) If the LIBOR rate is 3.5% in a given year, you will pay 0.5% of the notional value to your counterparty, but your counterparty will pay nothing to you

e) Your counterparty is most likely a Swap dealer since Swaps are traded over the counter (OTC)

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Outline

This Section: Options

- What are option contracts?
- What is the payoff of different option positions?
- How can they be used for speculation?
- How can they be used for risk management?
- Unfortunately, option pricing requires much more time to be properly taught and, thus, we will not cover it in this class. However, its pricing is also based on the "no arbitrage principle" we learned in the previous sections

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Example: Pension Fund Manager

- Suppose you are a pension fund manager holding a position on an equity index
- Your position is currently at $100 Million, but you are afraid equity markets will be too volatile over the next month (there will be a big macroeconomic announcement)
- One strategy is to leave the equity markets for the next month. However, this is costly and you lose any upside if the macroeconomic news turn out to be good
- Instead, you enter a contract with Citigroup in which you pay $1.5 Million today and they cover any equity loss in excess of 5% you have over the next month (i.e., you long a put option)
- Now, you are fine staying in the equity market since you know that your equity loss is limited to $5 Million (plus the $1.5 Million paid as a premium).

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Basics: What is an Option Contract?

- An option is a right to buy or sell an asset (called the underlying asset) at a given price (called the strike price) on or before a given time (called the expiration date).
- Option holders (or buyers) have a right (but not an obligation)
- Option writers (or sellers) have an obligation
- The payoff to option holders is never negative and, thus, they have to pay a premium for it.
- The payoff to option writer is never positive and, thus, they collect a premium upfront.
- It is not free to initiate a long position in options (unlike forward, futures and swaps).
- Most options are exchange traded (CBOE is the largest exchange), but there are some exotic options in OTC markets.

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Basics: Types of Options

- A call is an option to buy the underlying asset
- A put is an option to sell the underlying asset
- An European option can be exercised only at its expiration or maturity date (this does not mean it is traded in Europe)
- An American option can be exercised at or before maturity (it does not mean it is traded in America)
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- Many possible underlying assets available, but most common are Stocks, Foreign Currency, Stock Indices and Future Contracts

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Basics: Positions

- There are 4 positions you can have when trading options:
  - Long call: you pay a premium and hold an option to buy the underlying at a later date
  - Short call: you write a call for a premium and assume the obligation to sell the underlying at a later date
  - Long put: you pay a premium and hold an option to sell the underlying at a later date
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- Derivatives are zero sum games (like a bet): the profit of the long position is the loss of the short position and vice versa

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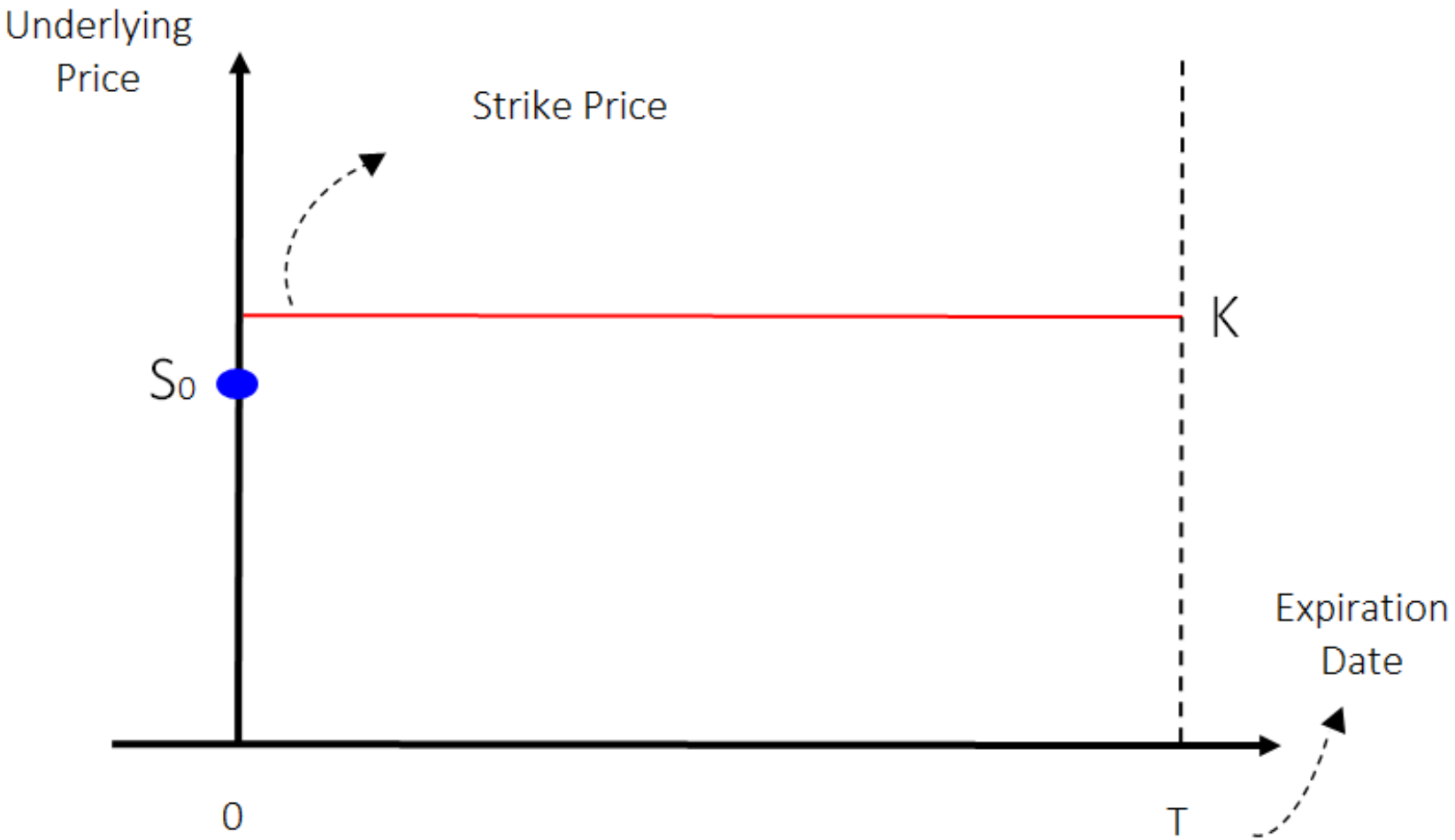
Call Options: Logic*



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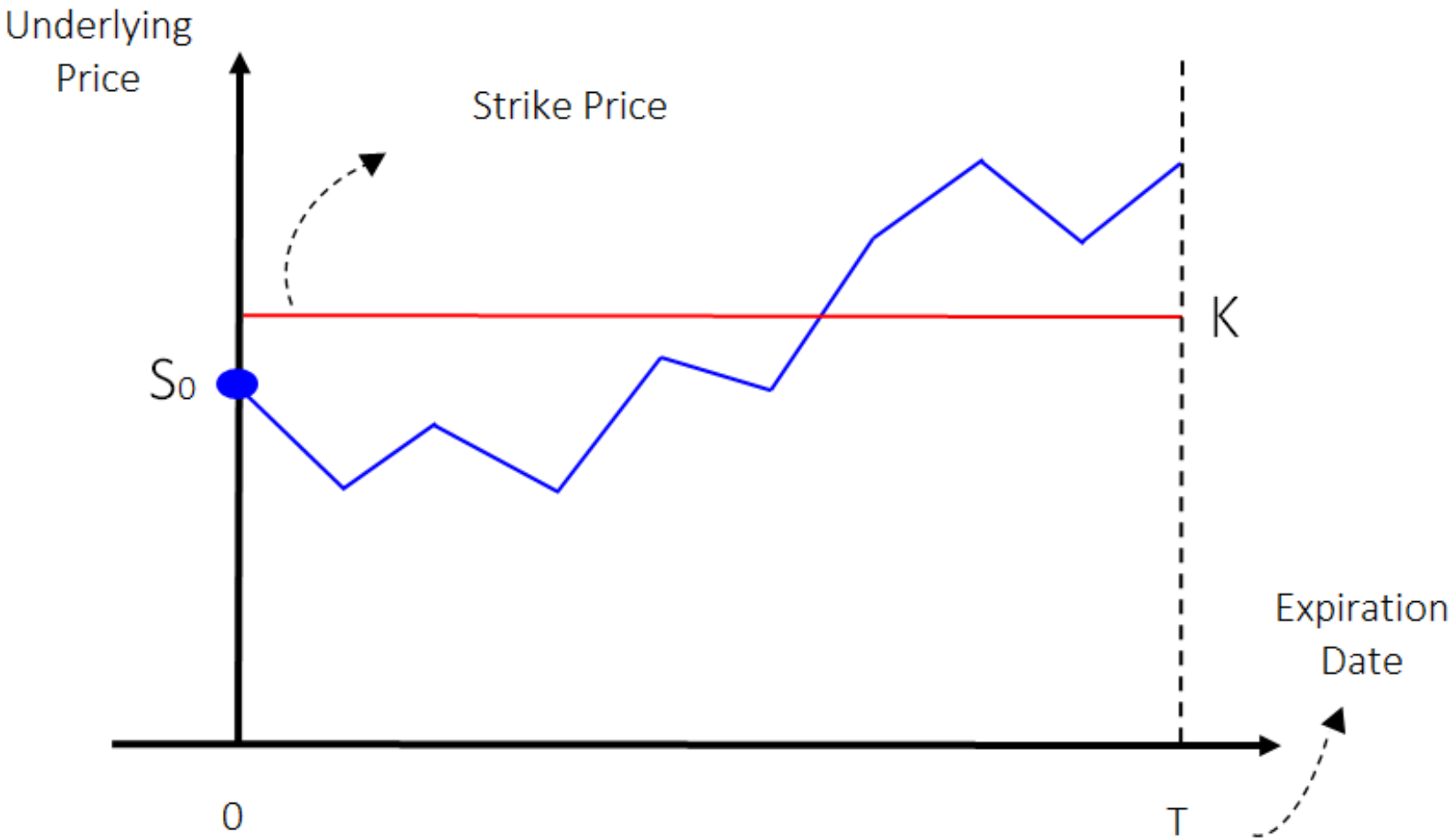

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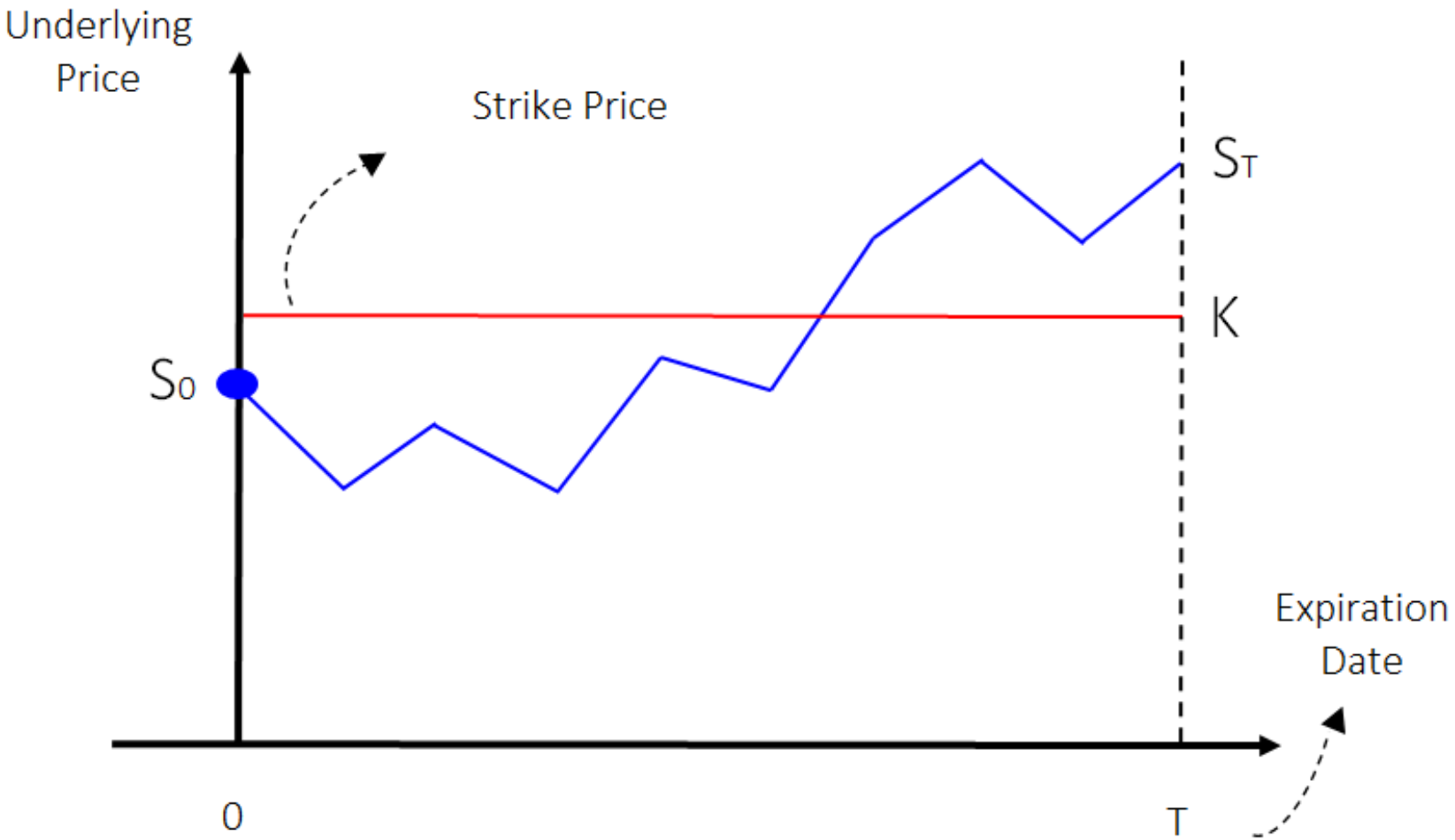

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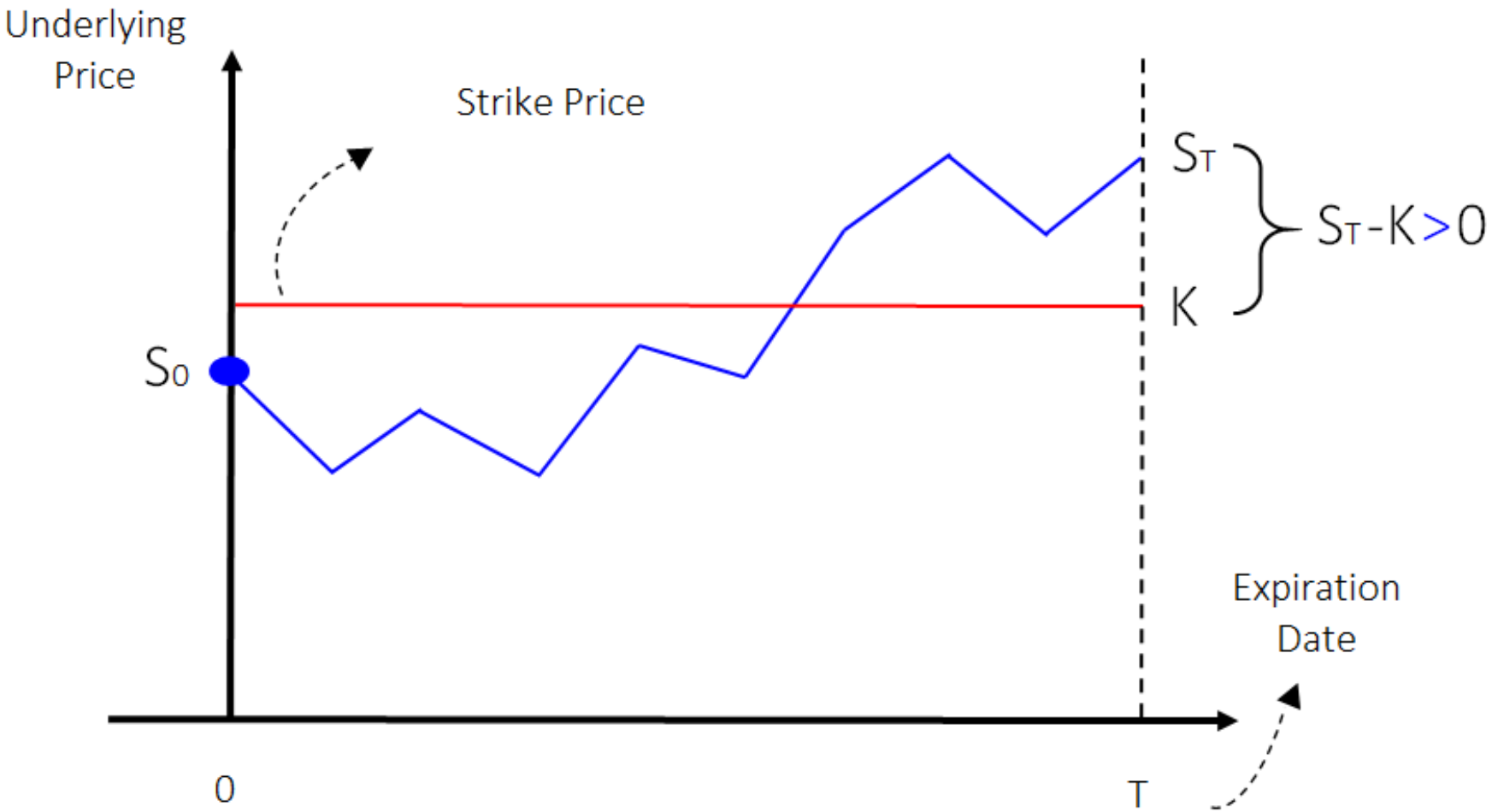

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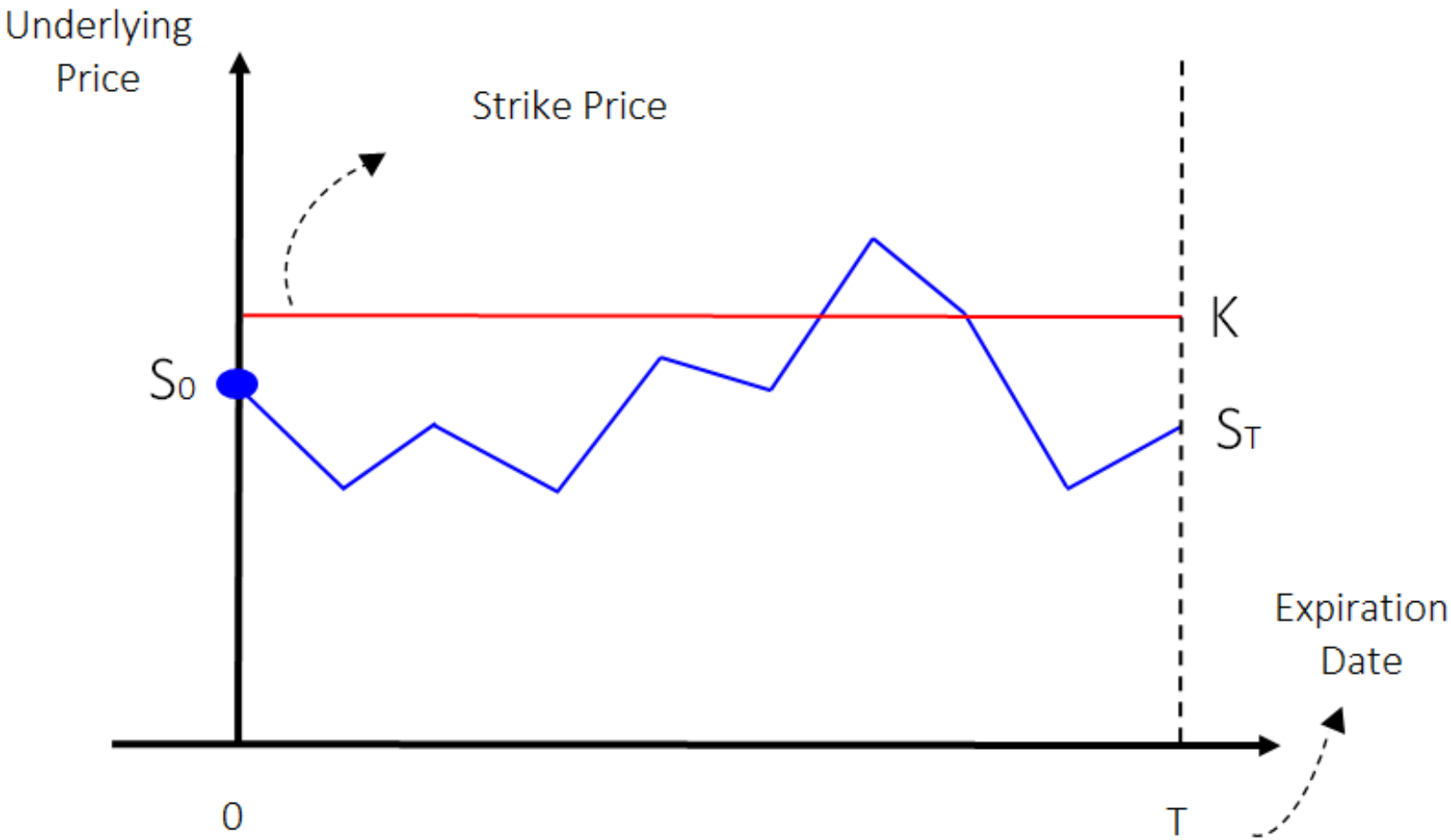

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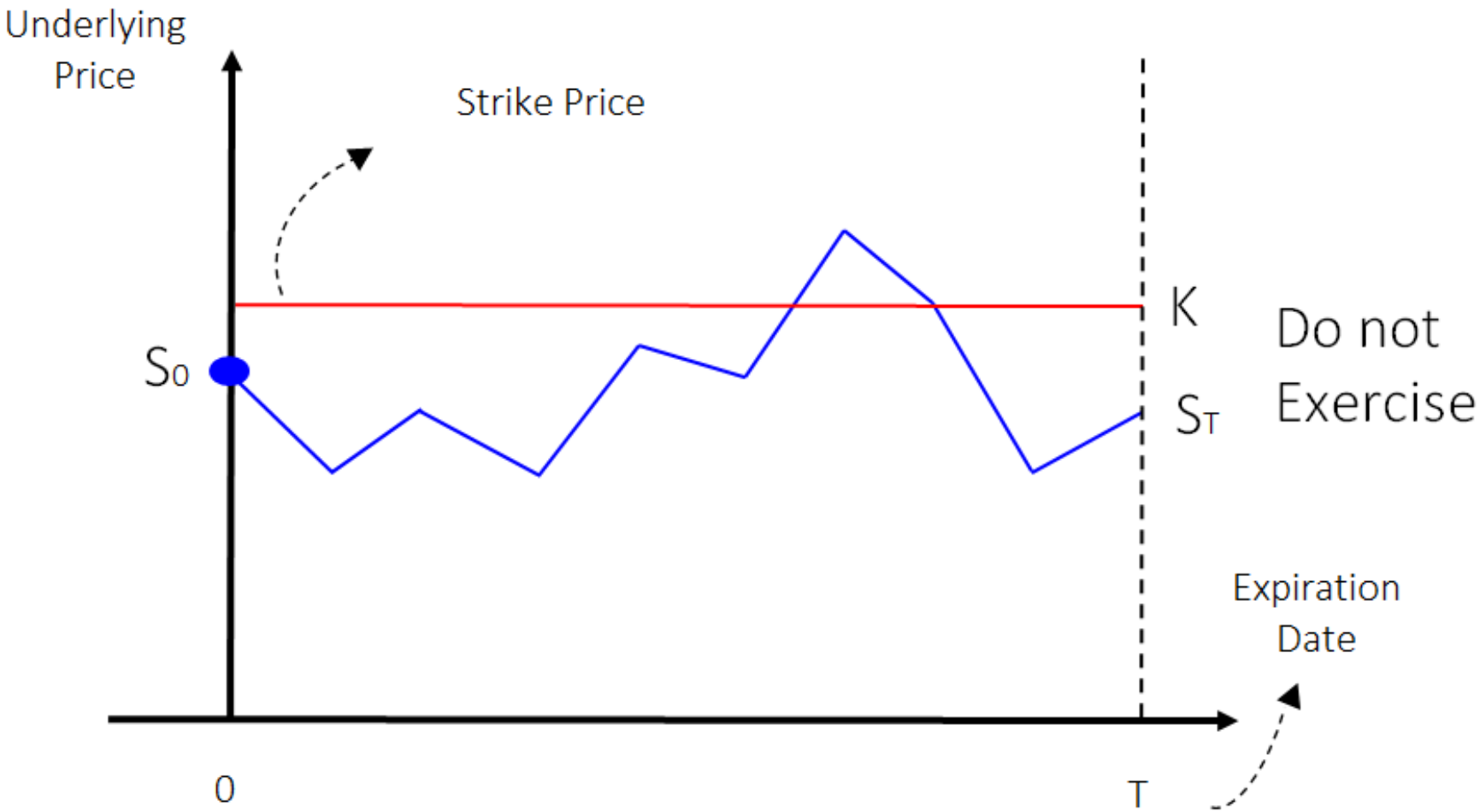
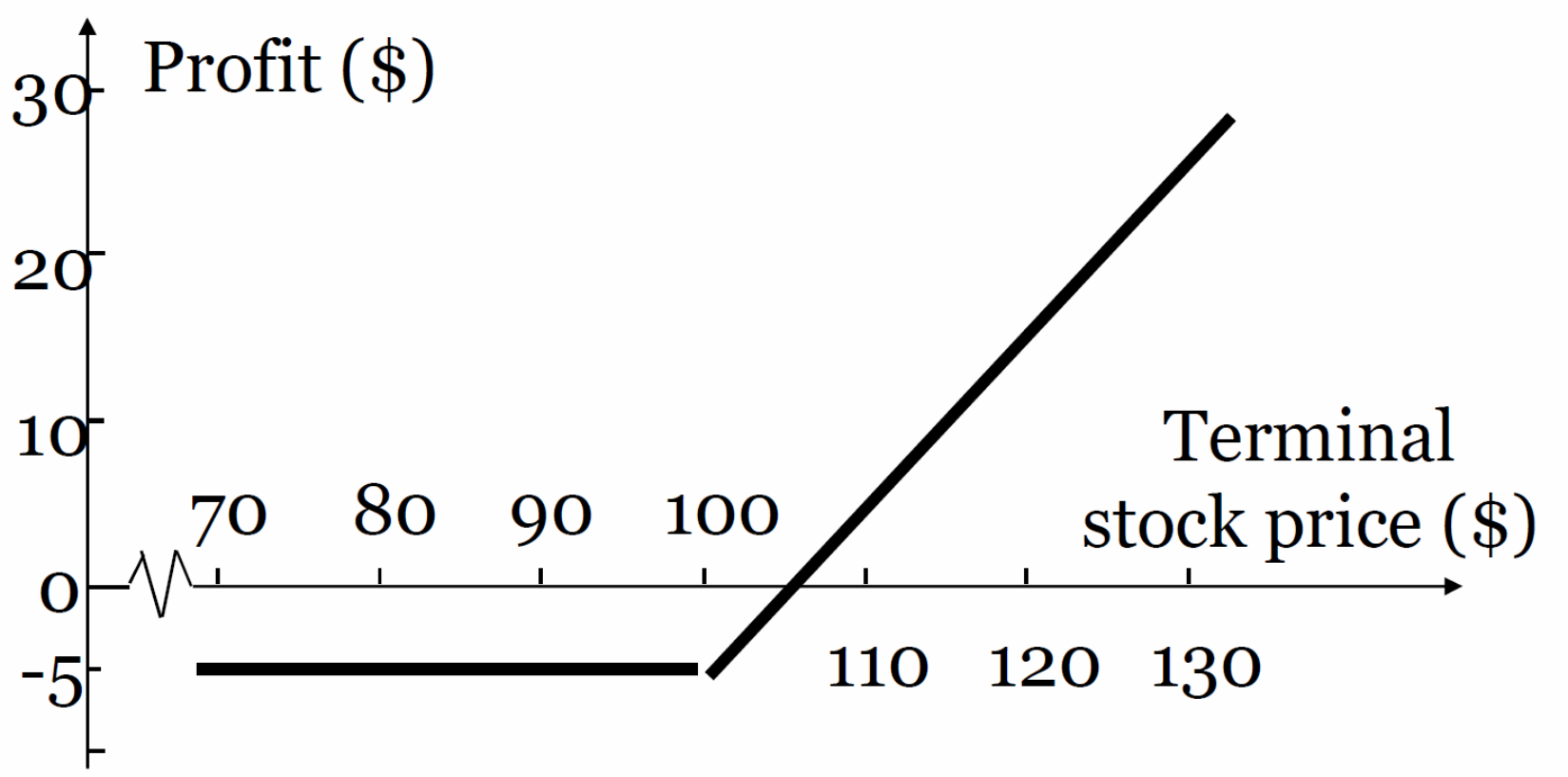
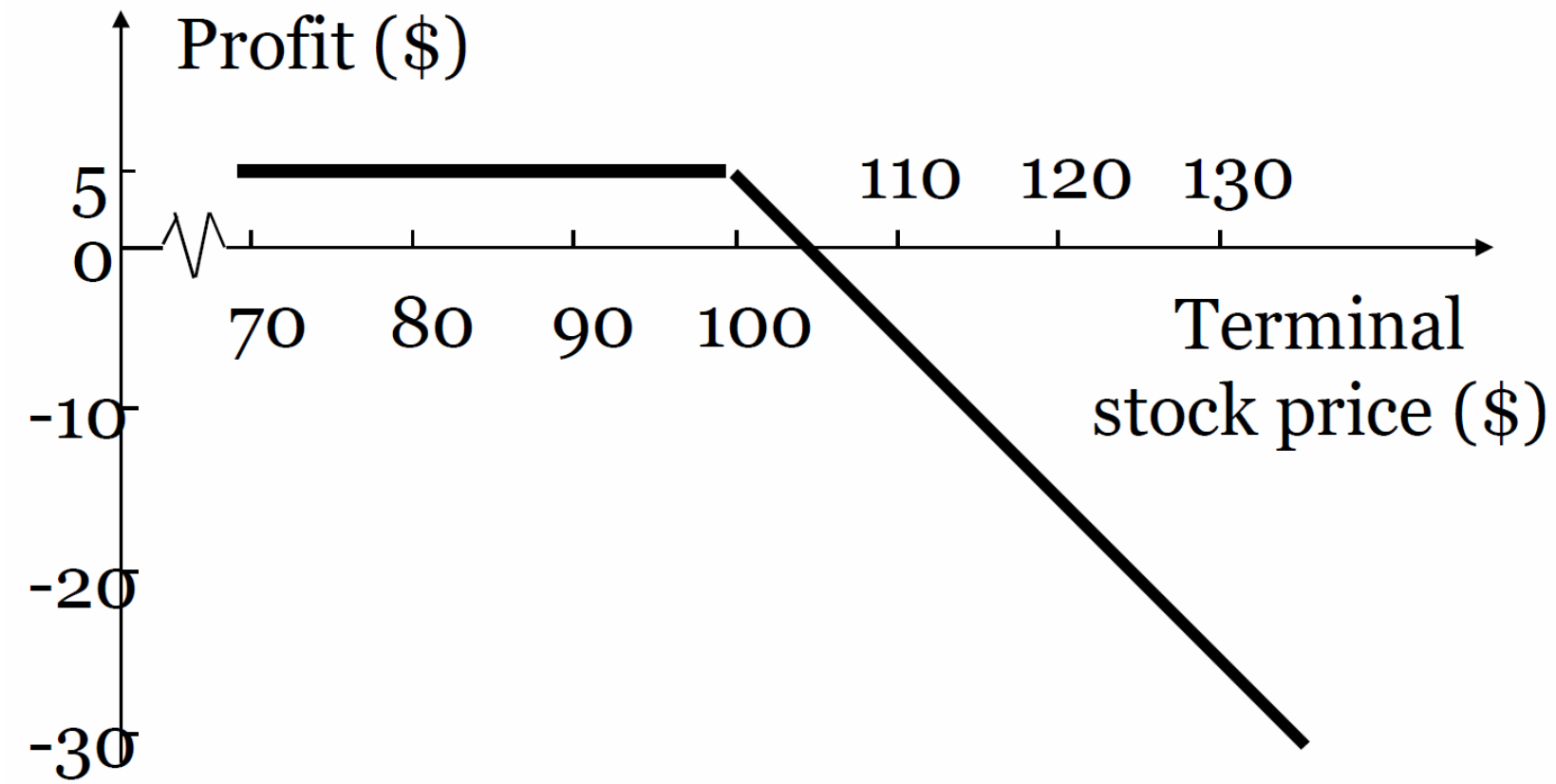


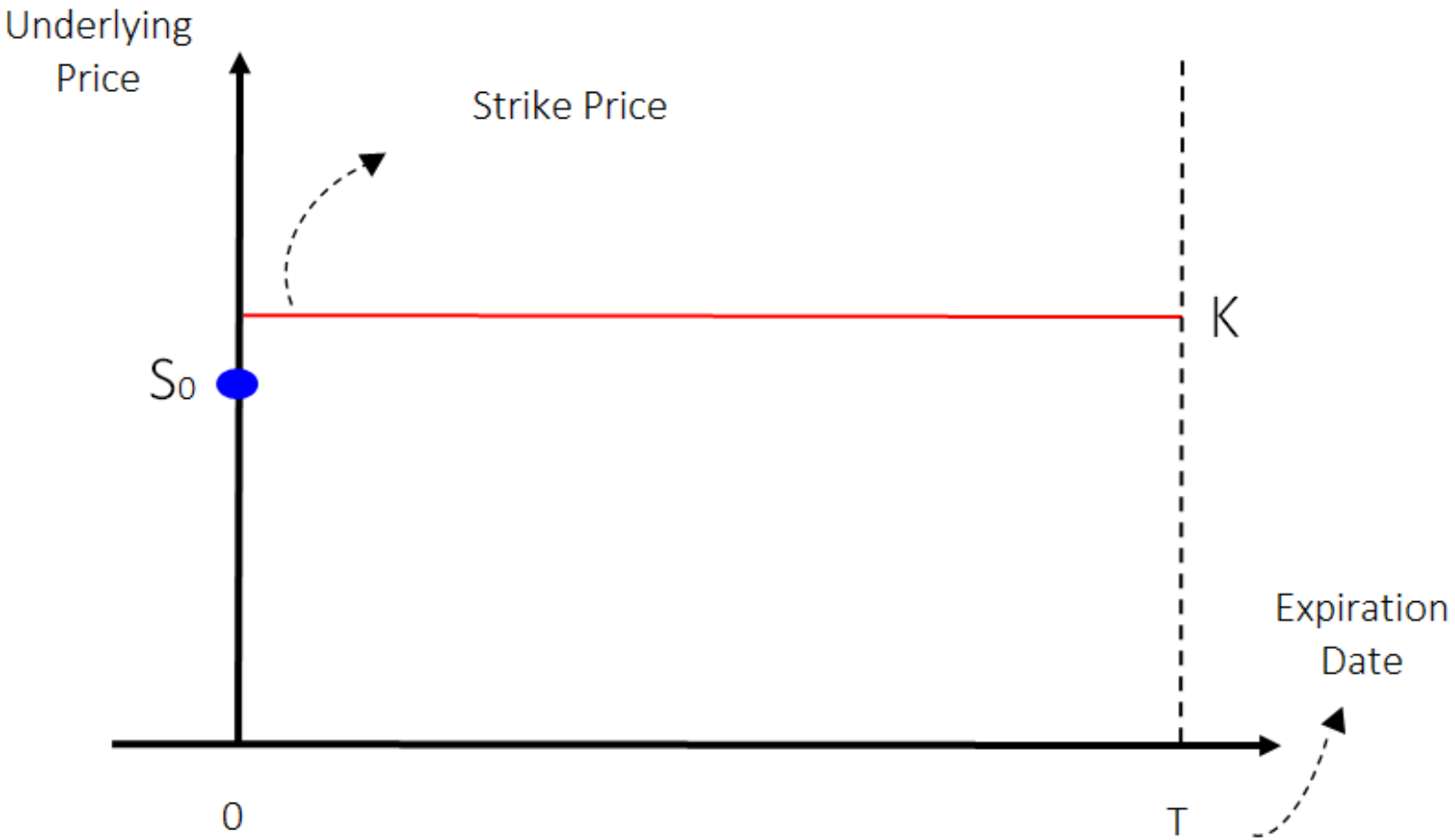
Call Options: Long Call Profit/Loss*



Call Options: Short Call Profit/Loss*



Put Options: Logic*



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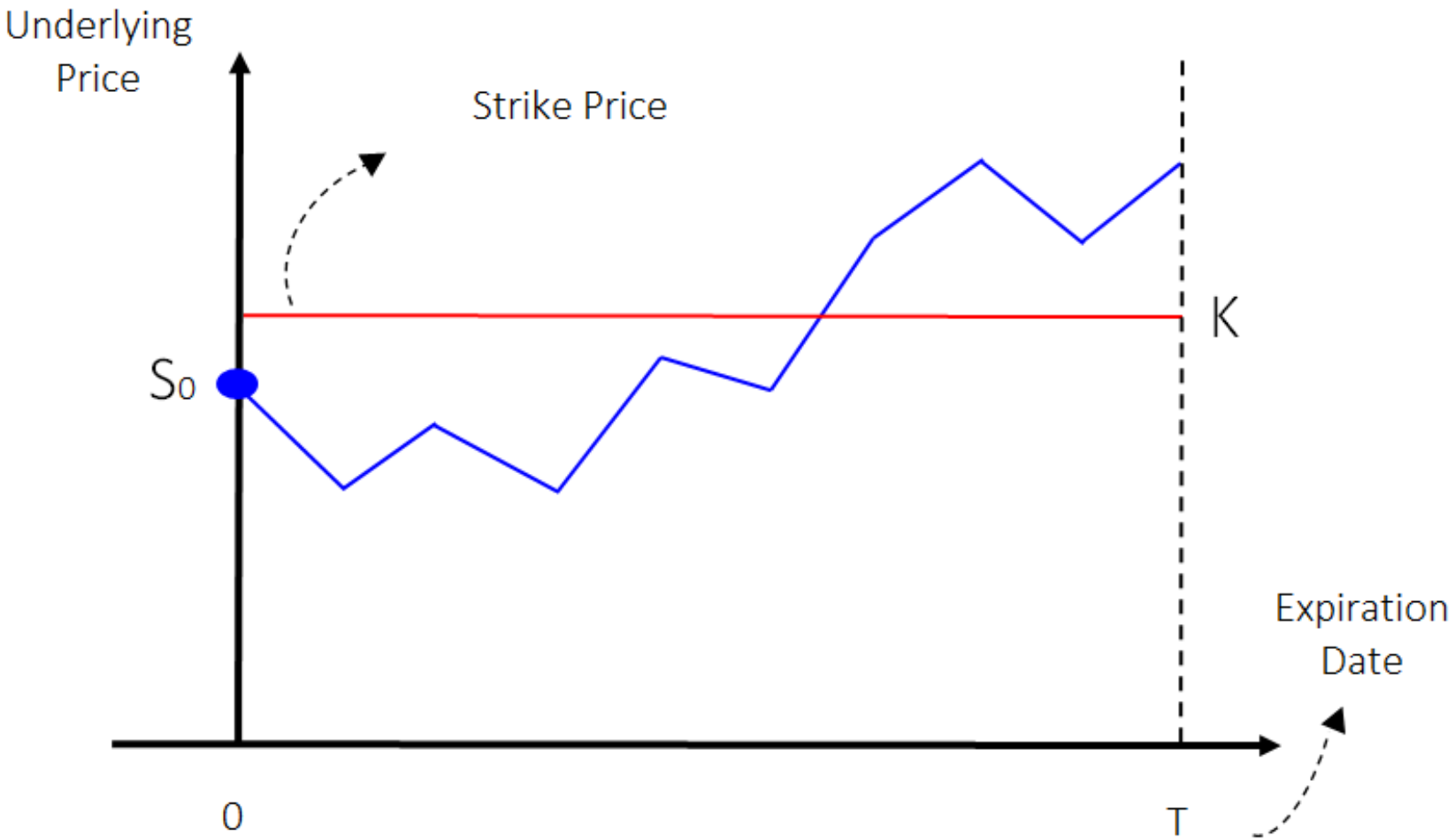

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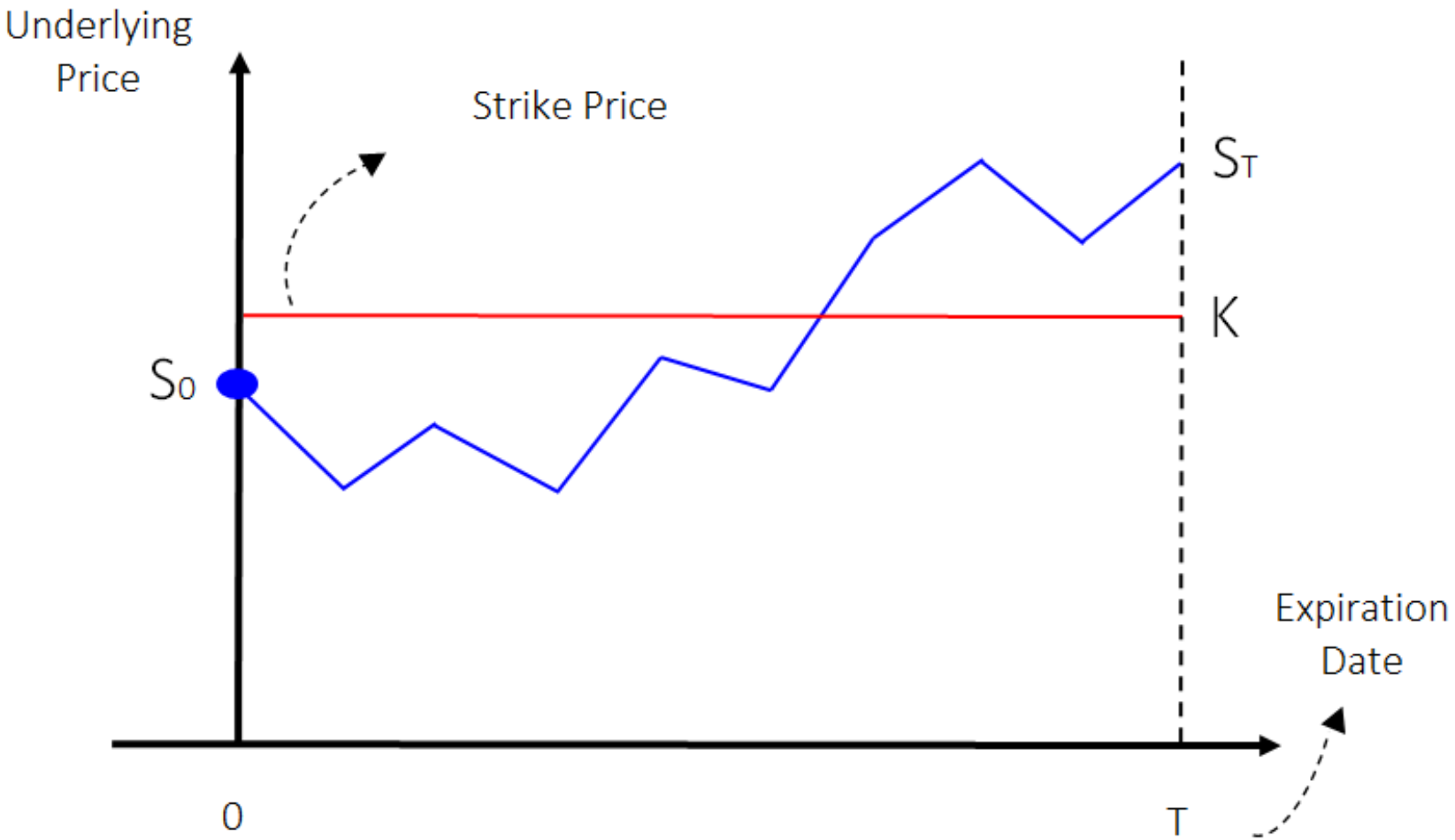

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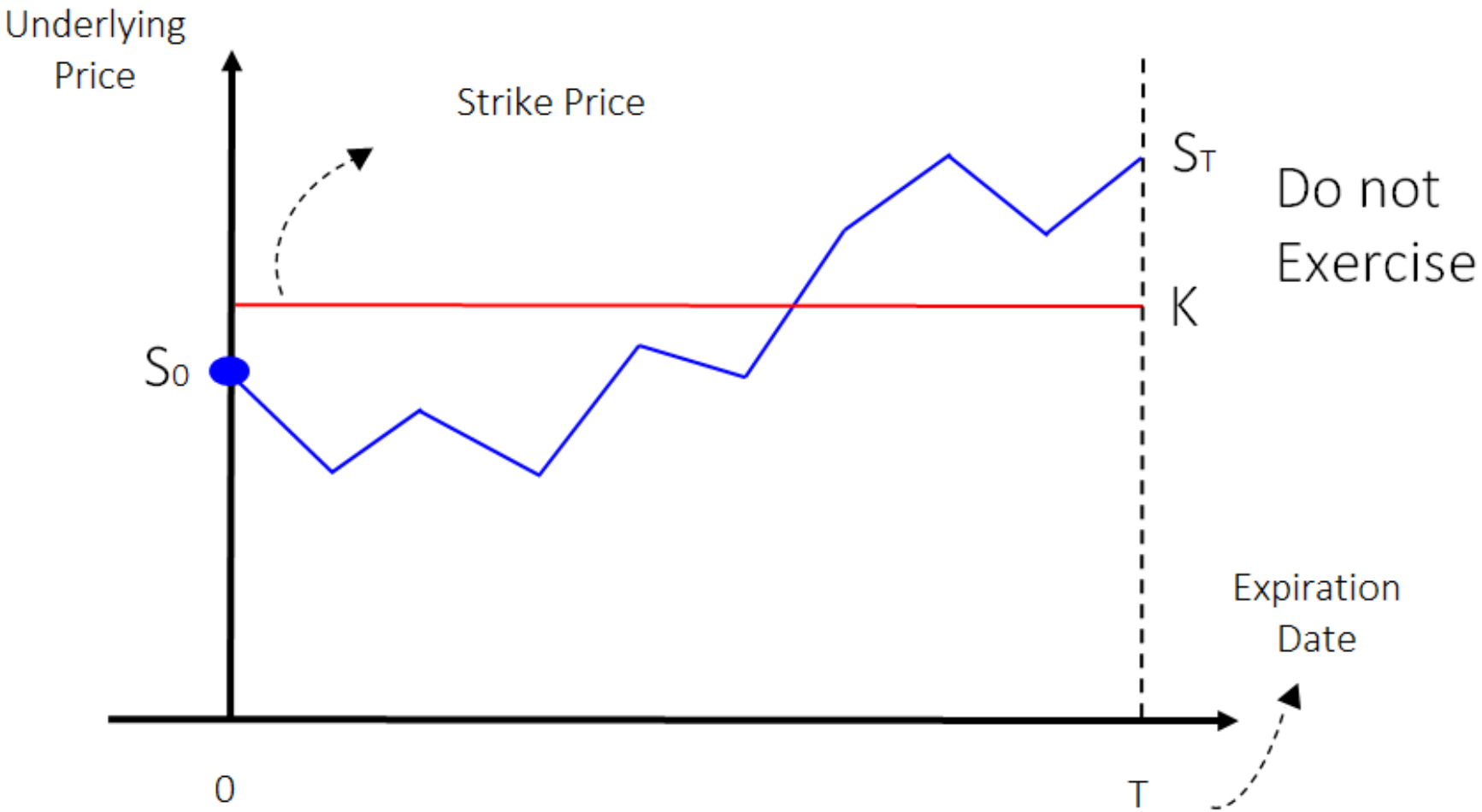

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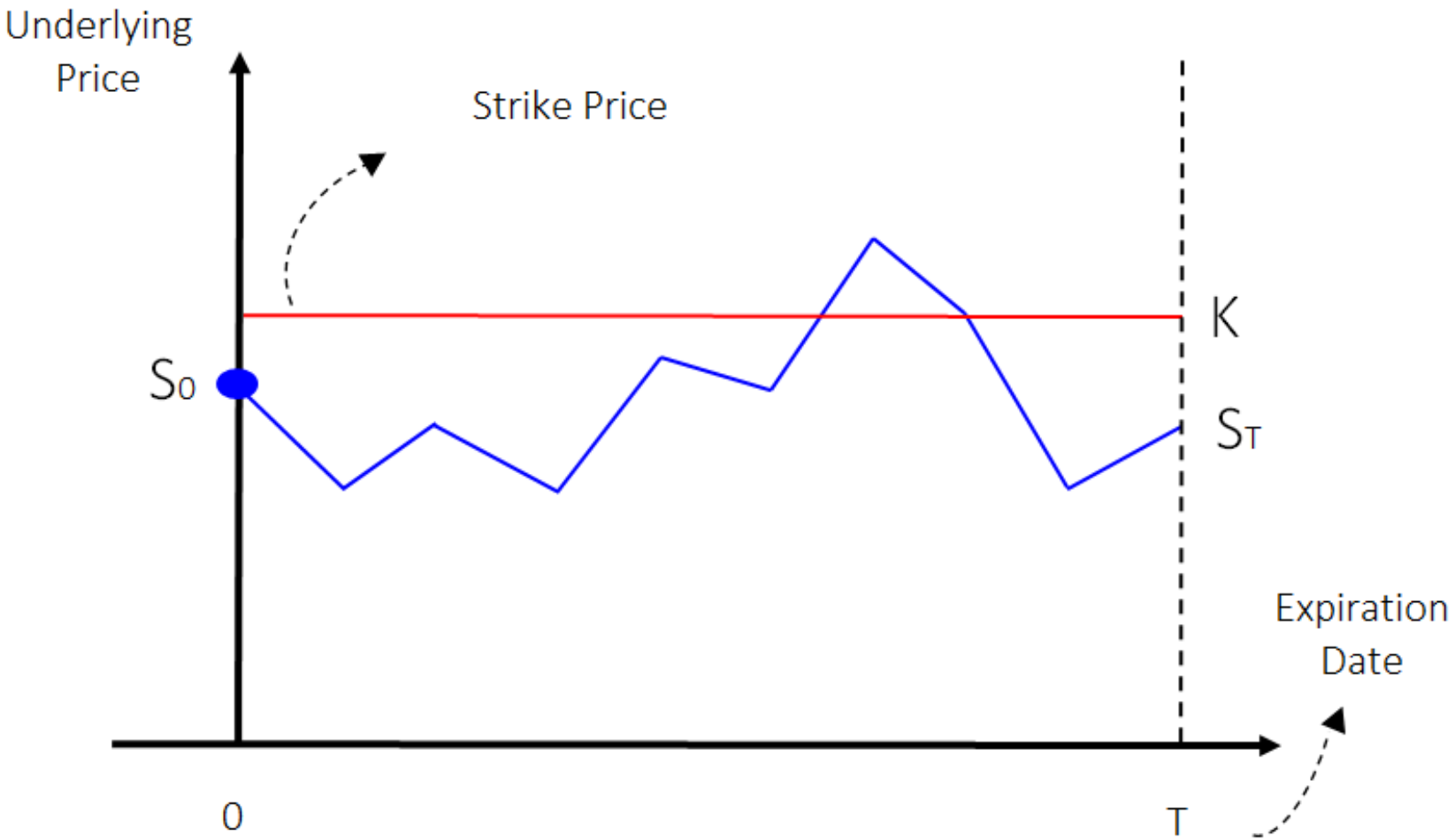

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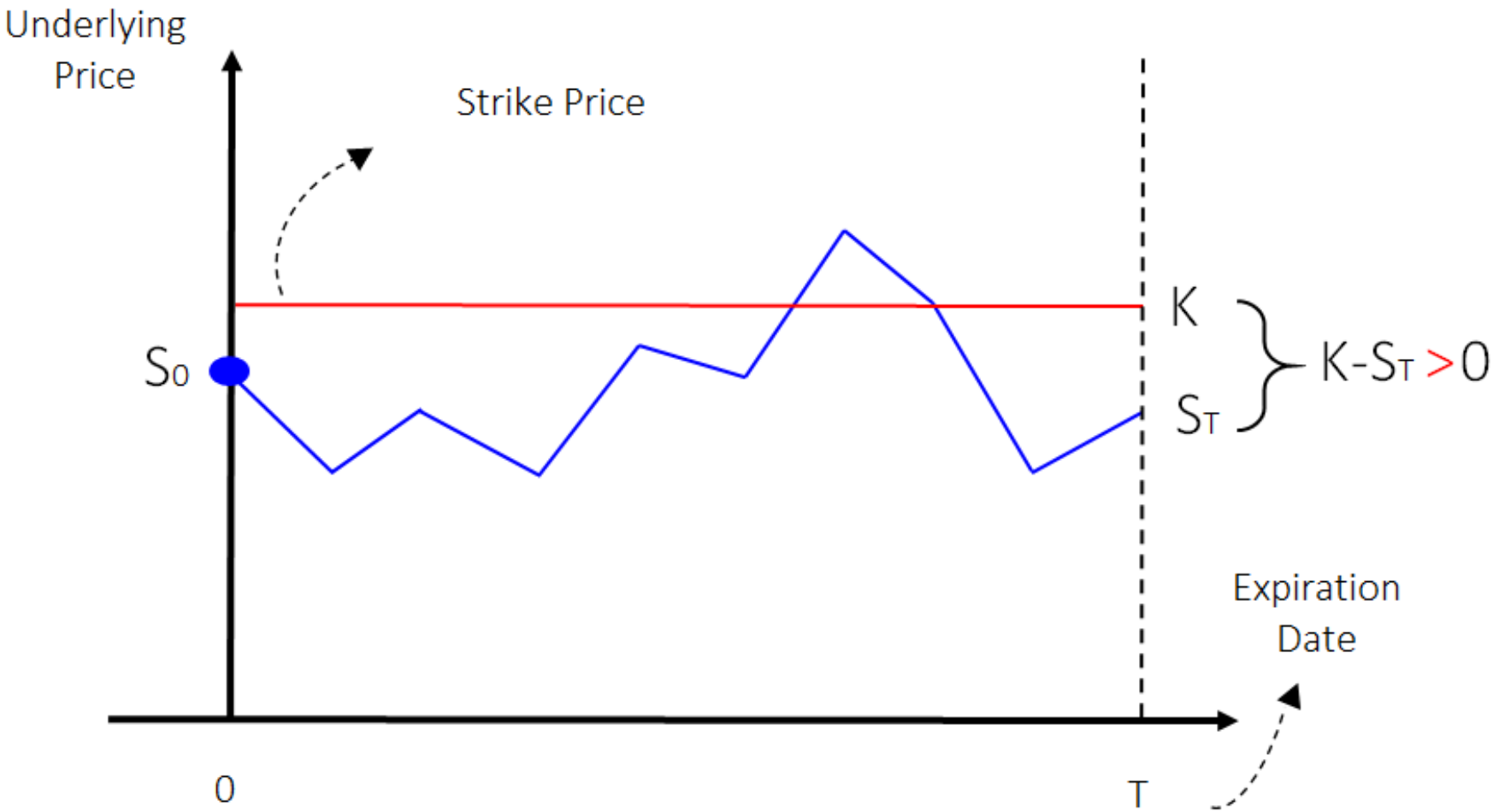
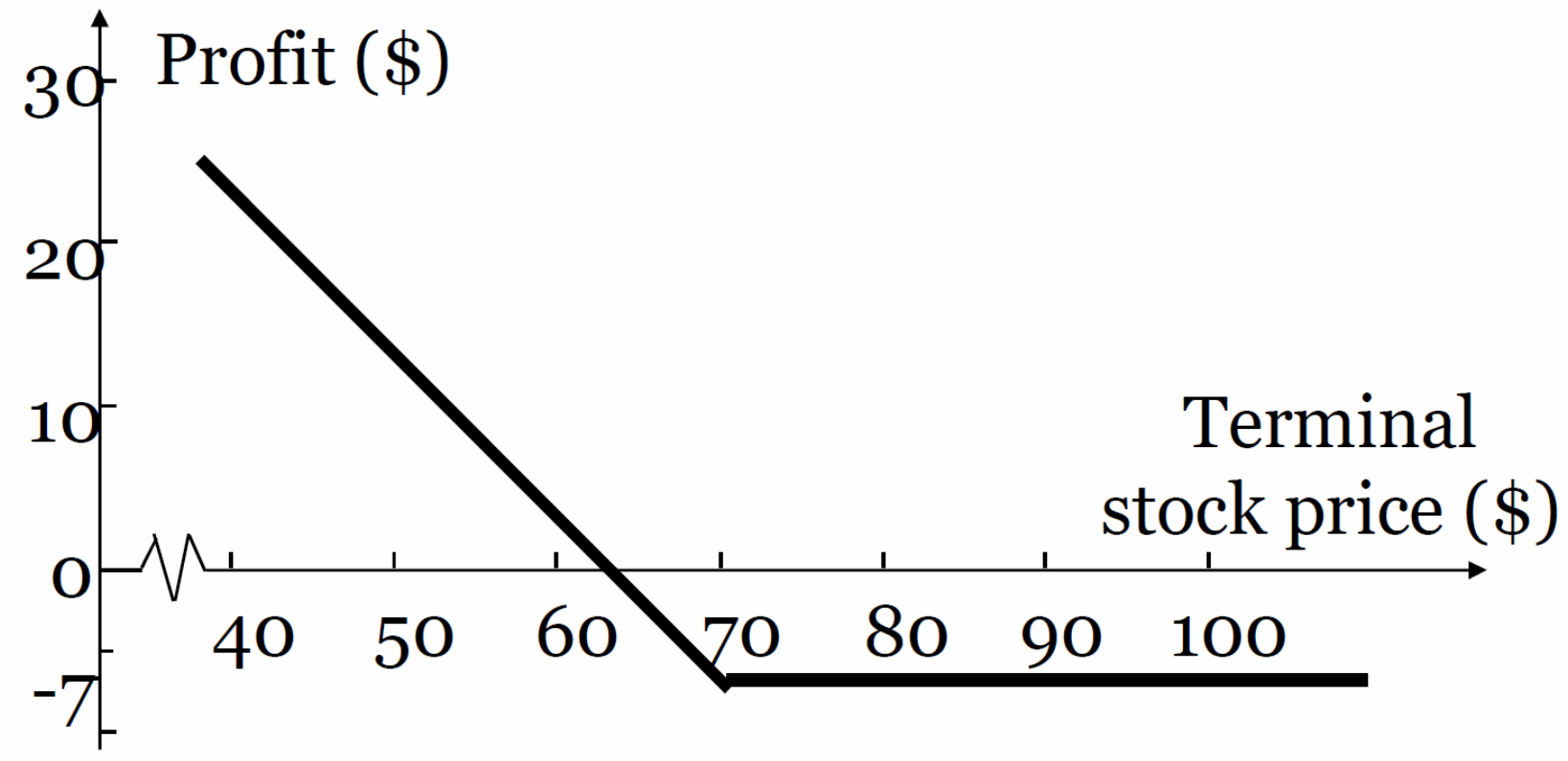
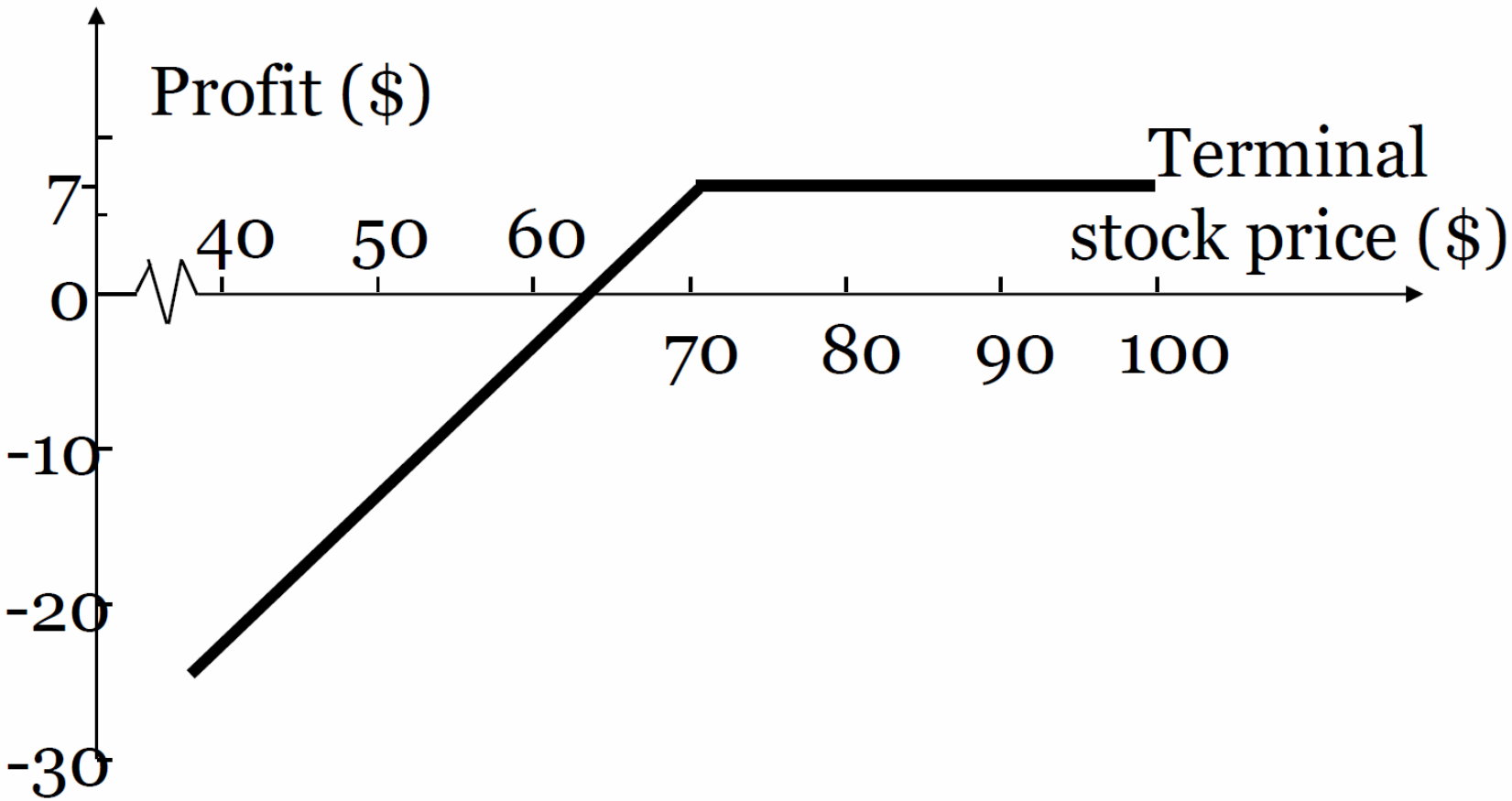


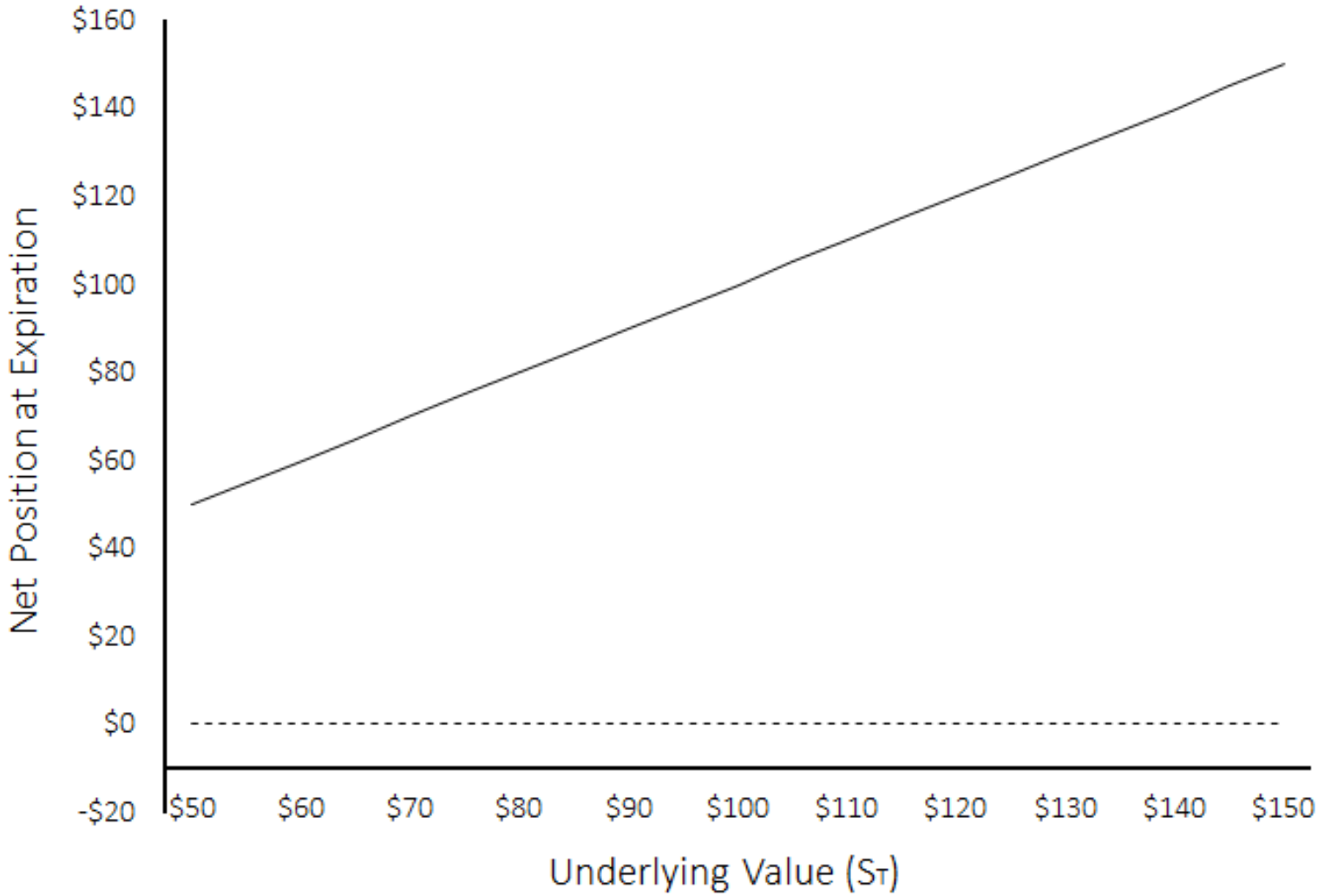
Put Options: Long Put Profit/Loss*



Put Options: Short Put Profit/Loss*



Put Options: The Protective Put*



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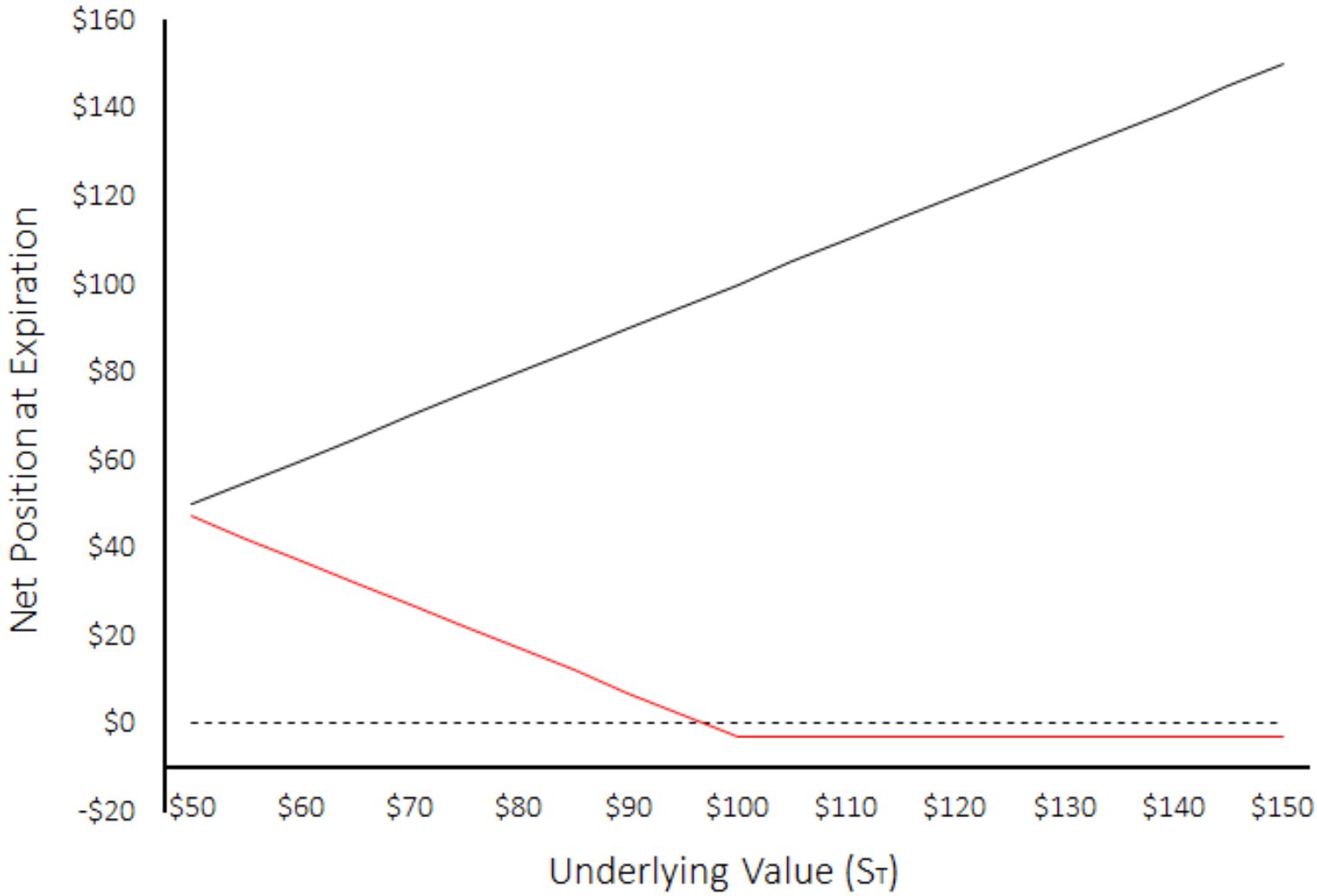

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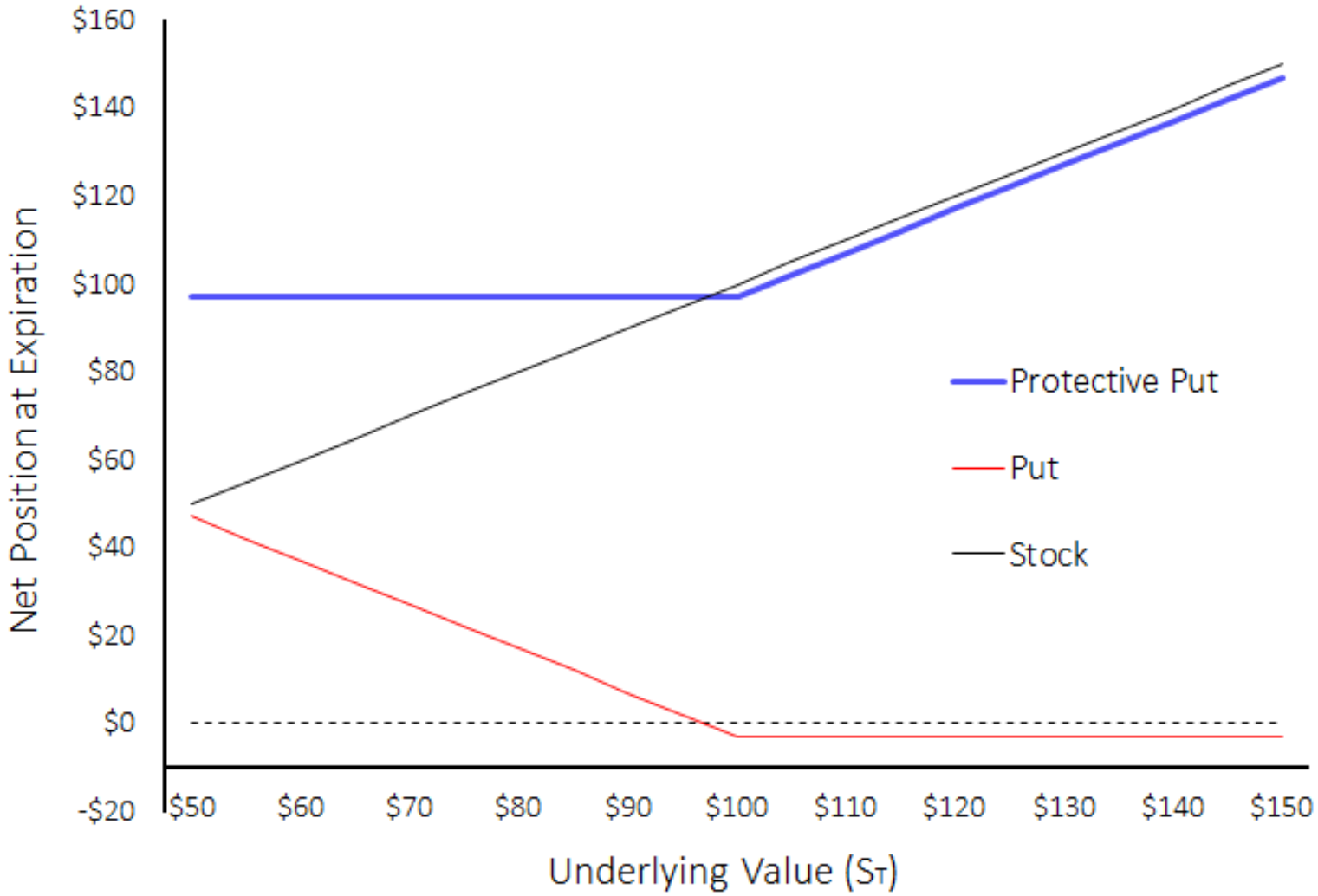

Creating Option Strategies

- Several put and call options trade at the same time (they have different maturities & strike prices).
- Traders refer to them based on their "Moneyness":
  - Some of the options would be profitable if exercised today (they are "in the money")
  - Other options would generate a loss if exercised (they are "out of the money").
  - Finally, some options have price equals to stock price and, thus, would result in a zero payoff if exercised today (they are "at the money").
- Combining different options can create alternative payoff structures that provide specific bets. These are very useful for speculation. Let's see some examples in excel.

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a) The payoff of writing a call is the same as the one from buying a put

b) If you buy a call option and the price of the underlying end up below the strike price, then you have to pay the difference at the end of the contract

c) A “at the money" call should be more valuable than a “in the money" call (with all other characteristics identical)

d) If you buy a protective put you are basically paying an insurance premium to limit potential downside losses of your position on the respective underlying asset

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