

Options Markets

Session 7& 8



Welcome

I am glad you are here



You have another
opportunity!

"NOTHING IS MORE
EXPENSIVE THAN A MISSED
OPPORTUNITY"

- H. JACKSON BROWN, JR.



विद्या परं देवतम्

IIM

VISAKHAPATNAM

Agenda

- Overview of Derivative Markets
- Call Option
- Put Option
- Properties of Options
- RBI Recent changes
- Put-Call Parity
- Binomial Option Pricing Model

Derivatives Markets in India

Derivatives Market in India

Impetus of developing a derivatives market in India came up with the setting up of the National Stock Exchange (NSE) in 1994, followed by NSCCL (1995) & NSDL(1996).

- L C Gupta committee Report (1998) recommended introduction of exchange traded derivatives.
- J R Varma committee Report (1998) worked out the operational details – Risk Management & margins.
- Securities Contracts (Regulation) Act, 1956 amended to include derivatives as a security (1999).
- Trading in F&O commences (on NSE):

Index Futures (June 12, 2000) **Currency Futures (USD)** (Aug. 29, 2008)

Index Options (June 4, 2001) **Interest rate Derivatives** (Aug. 31, 2009)

Stock Options (July 2, 2001) **Currency Futures (GBP, JPY, Euro)** (Feb 2010)

Stock Futures (Nov. 9, 2001) **Currency Options** (Oct. 29, 2010)

Derivatives Products in India

Equities (NSE, BSE, MCX-SX →MSEI)

- Index Futures & Options
- Individual Stock Futures & Options

Commodities (MCX, NMCE, NCDEX)

- Futures in \approx 113 commodities

Currencies

- Futures on 4 pairs of currencies :USD; EUR; GBP; JPY.
- Currency options are currently available on USD.
- Swaps & Forwards (OTC)

Interest Rate

- Interest Rate Forwards (OTC)
- Interest Rate Futures –91 days T-bills & 10 year bonds

Cash / Spot Market

In a Cash/Spot market, the three components of any transaction.

Price Negotiation ;

Clearing (*Determination of funds & asset obligations of each party*), &

Settlement(*Exchange of respective obligations*)

It takes place with 'no' or 'with minimal delay' (**on the spot**).

Cash / Spot Market

Suppose you wish to buy 43 kgs of Silver today.

Enquire about the price of the Silver.

- ✓The shopkeeper informs that it will cost Rs.37,870/-per kg of Silver.
- ✓If the price is agreeable to you, you decide to buy.
- ✓Shopkeeper then calculates how much you have to pay and set aside 43 kgs of Silver.
- ✓You pay Rs. 16,28,410/-and take delivery of 43 kgs of Silver.

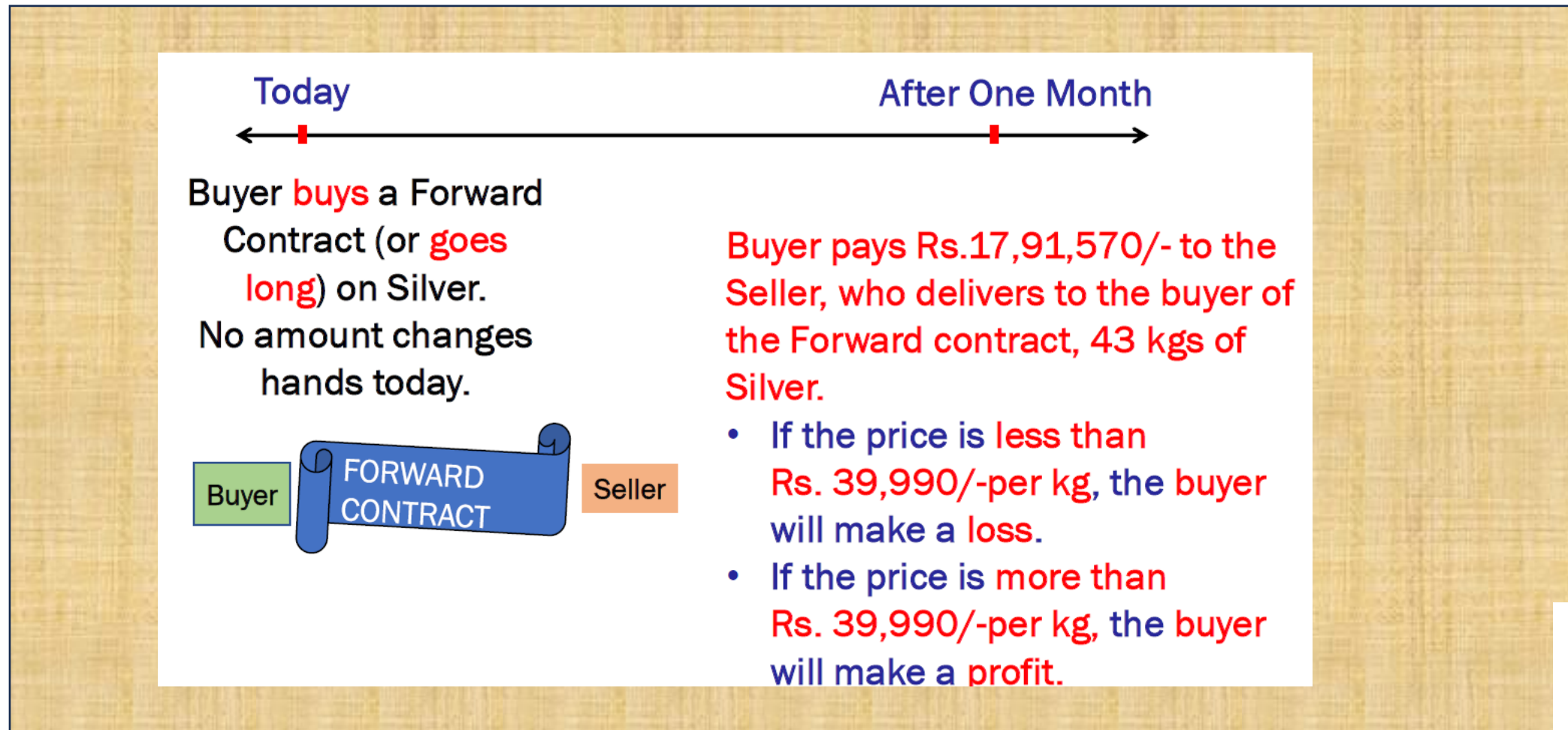
Forward Market

Now, suppose you wish to buy 43 kgs of Silver after one month, instead of today.

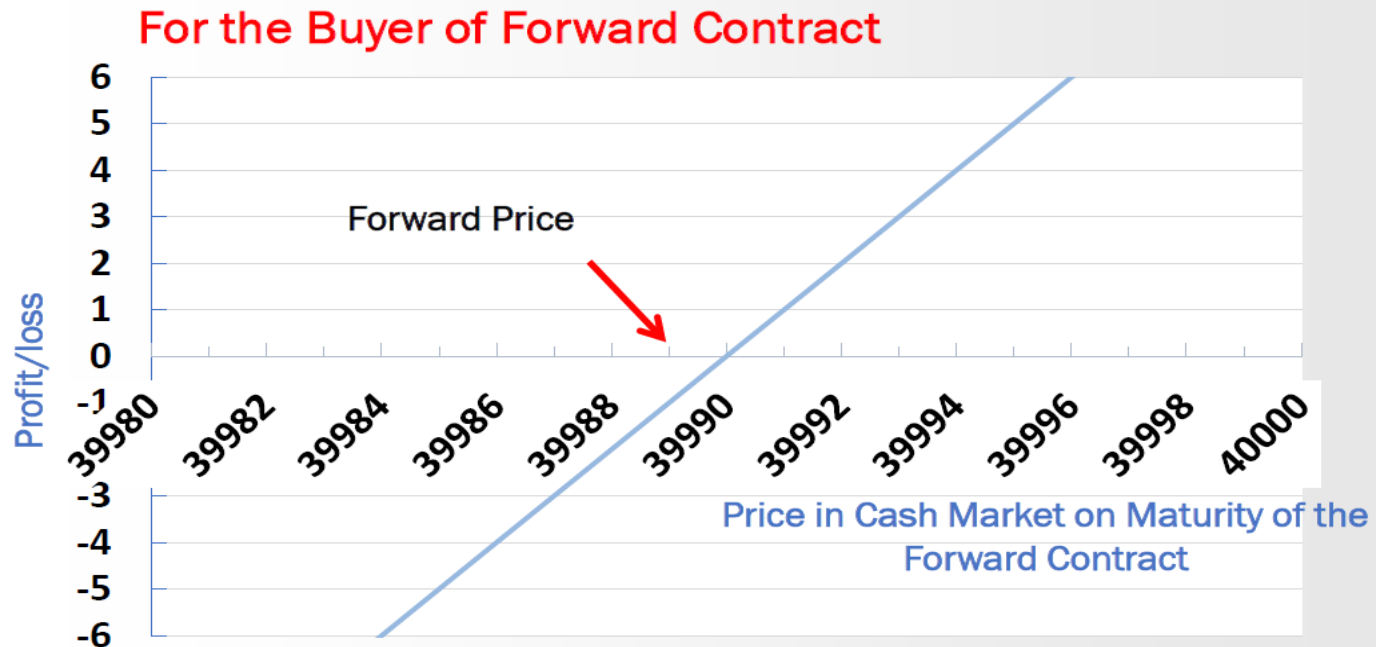
- ✓ You tell the store owner that you want to buy 43 kgs of Silver, *a month later*.
- ✓ The shopkeeper informs that it will cost Rs. 39,990/-per kg of Silver.
- ✓ If the price is agreeable to you, you decide to buy them a month later at the *one-month price* the shopkeeper has quoted.

One month later, you pay Rs 17,19,570/-and take delivery of 43 kgs of Silver.

Forward Market



Forward Market



- Pay-off (or Profit) from a **Long position** in the Forward Contract is: **Spot Price on Maturity (S_T) less Forward Price (F_0)**

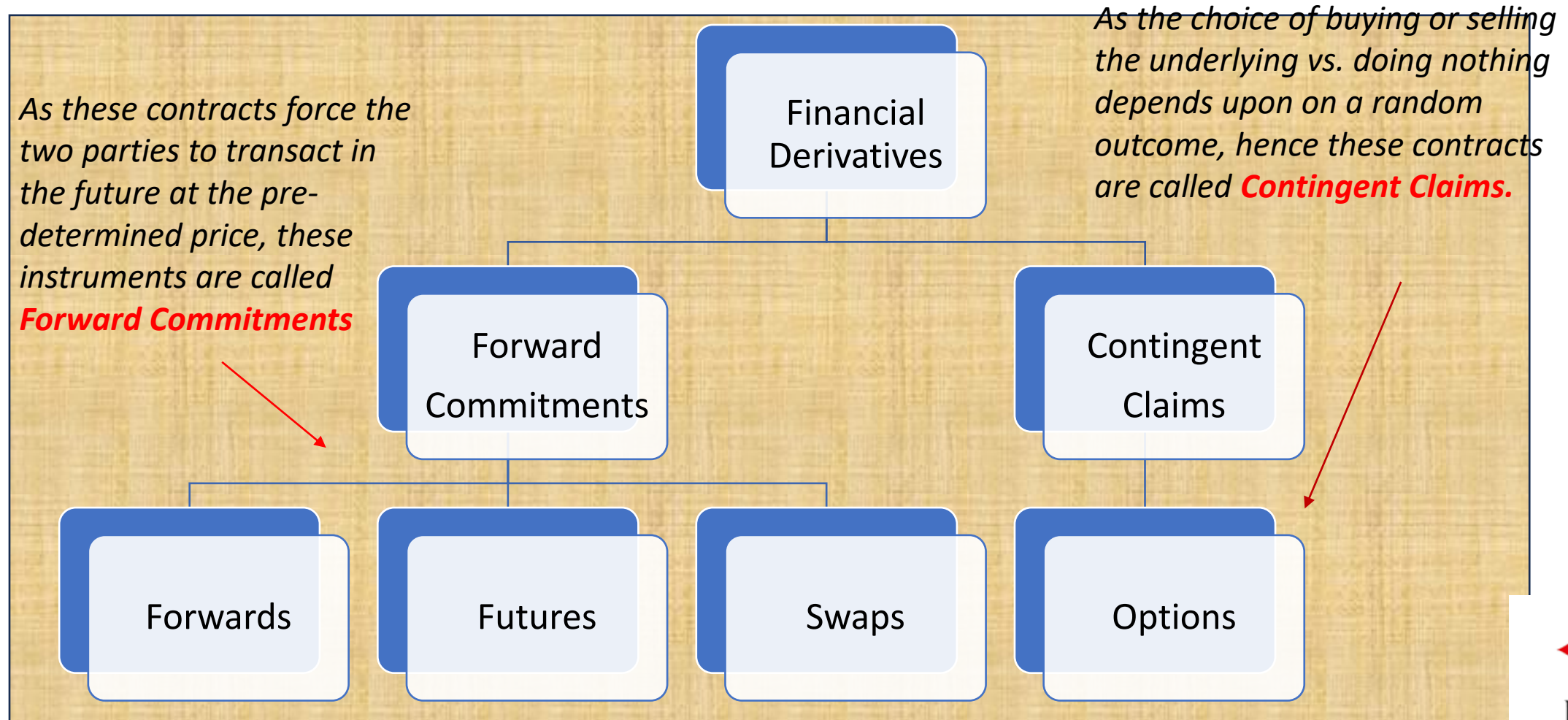
Pay-offs = profit/loss from the forward contract, as it costs nothing to enter into a Forward contract.

Forward Market



- Pay-off from a **Short position** in the Forward Contract is:
Forward Price (F_0) less Spot Price on Maturity (S_T)

Financial Derivatives



Options

Like forwards/futures, Options are derivative instruments that provide an opportunity to buy or sell an underlying asset at a pre-determined price & time.

- But in contrast, buying an Option gives the *right*, not the obligation to buy or sell an underlying asset.
- Buyer of the Option may buy (or sell) the underlying asset at the predefined price, on or before the expiry of the contract.
- Basic types of Options are:
 - ✓ Call Option
 - ✓ Put Option

Options

A Call Option gives the buyer:


- ✓ the right, but *not the obligation*
 - ✓ to buy a specified asset from the seller (of Call option)
 - ✓ for a pre-determined exercise price
 - ✓ on or before a fixed expiration date in the future
 - ✓ by paying the call option premium or price, now.
- On (or before) expiration date, the call buyer may choose to exercise the call option, wherein he would pay the exercise price and receive the asset from the seller (of call option).
- Alternatively, he may choose not to exercise the call option, then the call option simply expires worthless.

Options

Today(Jan 1), the price of ABCL stock is Rs. 60/-. The Call option on ABCL stock at different exercise prices with Expiration Date as April 15 are available as below.

Exercise Price	Call Price
60	13.75
65	12.90
70	9.50
75	6.70
80	4.50
85	3.00
90	2.25
95	1.75
100	1.35
105	0.85

You decide to buy a Call option with exercise price of Rs80/-for Rs.4.50



Options

January 1

April 15

← Pay Rs.4.50 →

If the stock price > Rs 80/- (say Rs 90/-):

You will like to exercise the Call Option

- Buy the stock for Rs 80/- (and sell immediately the stock for Rs 90/-) ,
- Pay-off of Rs. 10/- (Rs 90 – Rs 80), &
- Profit of Rs. 5.50 (Rs 10 – Rs 4.50)

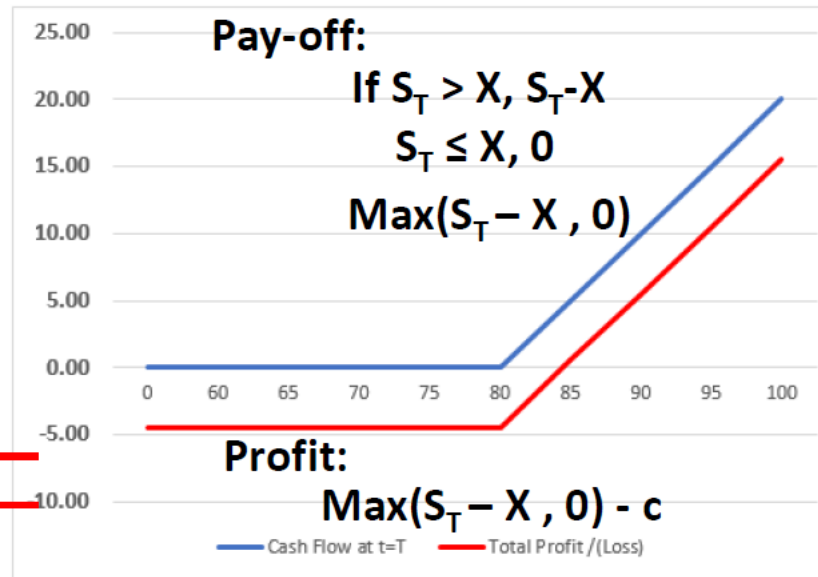
If the stock price < Rs 80/-,(say Rs 65/-)

You will not exercise the Call Option, and let the Call expire worthless.

- Pay-off of Rs. Zero/- &
- Profit of - Rs. 4.50 (loss)

Pay-off & Profit (Loss) for Call Option Holder

	Stock Price on April 15	Cash Flow at t=0	Will Buyer exercise Call Option?	Cash Flow at t=T	Total Profit/(Loss)
1	Call Price on January 1	4.50			
2	Exercise Price (X)	80.00			
3					
4					
5	0	-4.50	No	0.00	-4.50
6	60	-4.50	No	0.00	-4.50
7	65	-4.50	No	0.00	-4.50
8	70	-4.50	No	0.00	-4.50
9	75	-4.50	No	0.00	-4.50
10	80	-4.50	Indifferent	0.00	-4.50
11	85	-4.50	Yes	5.00	0.50
12	90	-4.50	Yes	10.00	5.50
13	95	-4.50	Yes	15.00	10.50
14	100	-4.50	Yes	20.00	15.50



Pay-off & Profit (Loss) for Call Option Seller

Stock Price on April 15	Cash Flow at t=0	Will Call Buyer exercise Call Option?	Cash Flow at t=T	Total Profit /(Loss)
0	4.50	No	0.00	4.50
60	4.50	No	0.00	4.50
65	4.50	No	0.00	4.50
70	4.50	No	0.00	4.50
75	4.50	No	0.00	4.50
80	4.50	Indifferent	0.00	4.50
85	4.50	Yes	-5.00	-0.50
90	4.50	Yes	-10.00	-5.50
95	4.50	Yes	-15.00	-10.50
100	4.50	Yes	-20.00	-15.50



Let's Take a small break from Options and analyse a recent move by RBI and its impact on Economy

RBI Tightens Capital Norms for Unsecured Loans

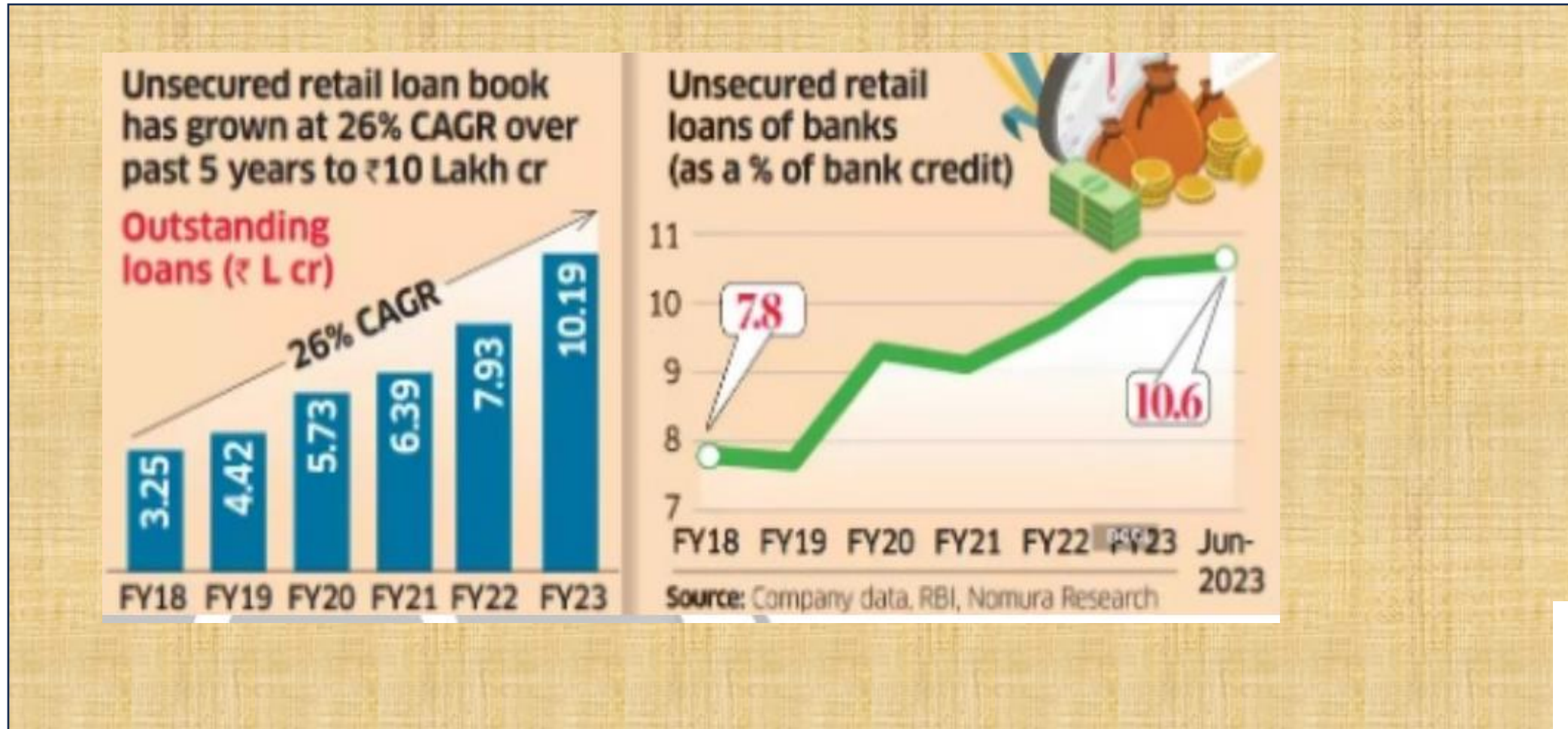
RBI has increased Risk Weight on Bank Exposure to check on Unsecured Loans, like Personal Loans, Credit Card Receivables etc.

The RBI has raised the risk weight on banks' exposure to certain categories like consumer credit, credit card receivables, and NBFCs.

The risk-weights on banks' unsecured personal loans and consumer durable loans have been increased to 125% from 100%, and that on credit cards have been increased to 150% from 125%.

Further, the risk-weights on NBFCs' unsecured personal and consumer durables loans, and credit cards have been increased to 125% from 100%. It means that banks and financial institutions need to set aside more capital as a buffer against potential losses arising from these specific loan categories.

RBI Tightens Capital Norms for Unsecured Loans



RBI Tightens Capital Norms for Unsecured Loans: Need for Such a Move

- ✓ **Control Unbridled Growth:** Unsecured Loans, especially consumer Loans, had been expanding rapidly, surpassing the growth rate of less risky lending assets. This unchecked growth could pose risks to the stability of the financial system.
- ✓ **These loans are not backed by collateral,** making them riskier for lenders. If borrowers' default on these loans due to economic downturns or personal financial issues, it can lead to significant credit losses for banks and other lending institutions.
- ✓ **Prevent Escalation of Risk-** Establishing board-monitored processes for these advances helps ensure that banks have proper risk assessment mechanisms in place. This step intends to prevent the escalation of risk associated with unsecured retail lending
- ✓ **Maintain Financial Stability-** The overarching goal is to maintain financial stability by addressing the imbalance in lending practices and ensuring that the rapid growth in unsecured retail loans doesn't pose a systemic risk to the banking and financial sectors

What is the Current Scenario of Unsecured Credit for Banks?

- ✓ Unsecured credit, excluding microfinance institutions, for large banks is only about 5-13% of their total loans.
- ✓ Further, loans extended to NBFCs constitute another 5-12% for banks.
- ✓ According to analysts' estimates, the share of the total impacted book, which is NBFC and unsecured loans, is the lowest for IndusInd Bank at 10%, and ranges from 15 to 20% for other major banks.
- ✓ Among NBFCs, the most affected would be SBI Cards, as 100% of the loans are unsecured.
- ✓ The next would be Bajaj Finance as unsecured loans form 38% of the total loan, followed by Aditya Birla Capital with a 20% exposure in unsecured consumer loans.

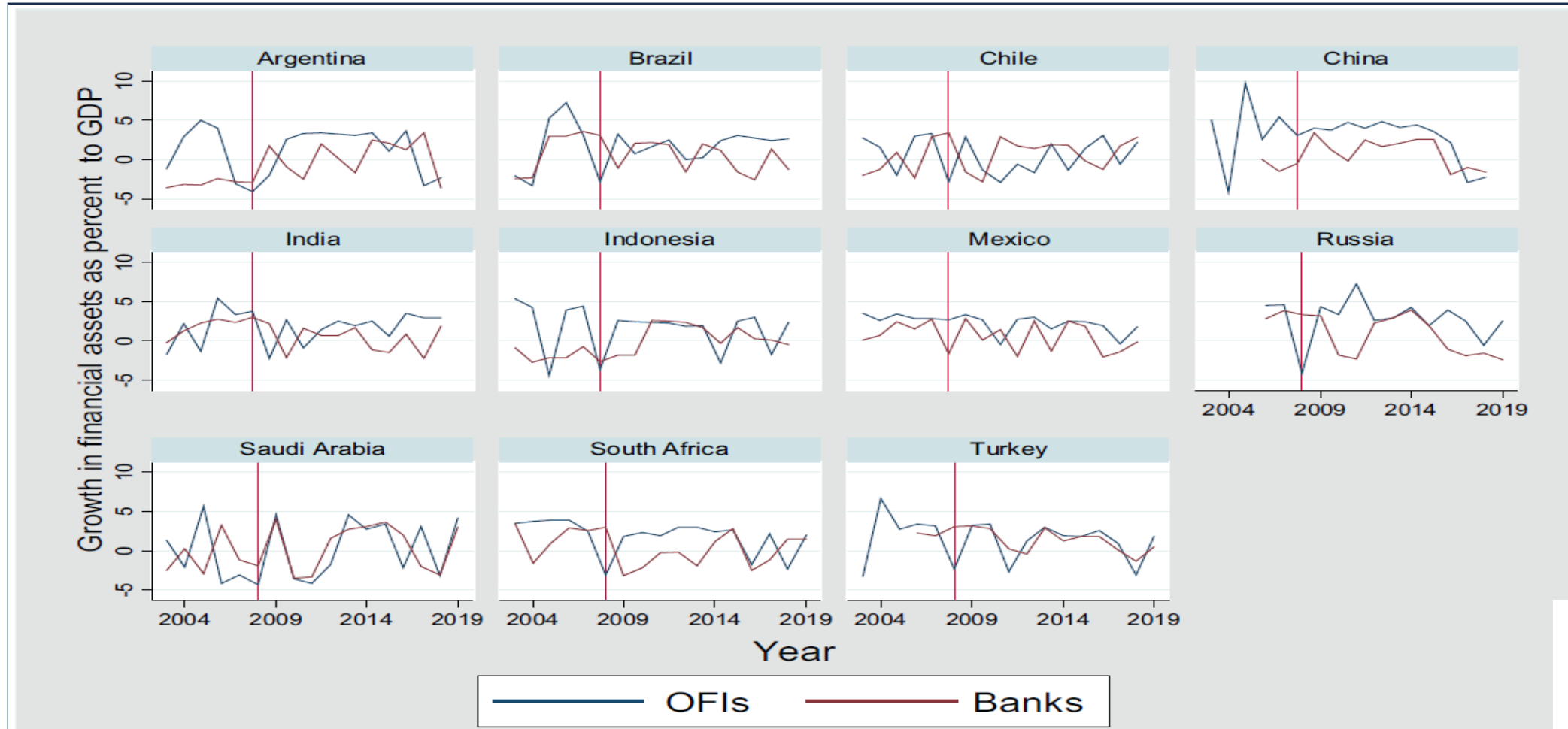
Way Forward

- ✓ Banks and NBFCs may need to reassess their risk models and lending practices for unsecured loans.
- ✓ They might focus more on creditworthiness assessments and consider alternative strategies to manage risk while continuing to lend.
- ✓ Financial institutions might diversify their loan portfolios by shifting focus to more secured lending or exploring other creditworthy segments to balance the impact of increased risk-weighting on unsecured loan.

What our research says???

- As per (FSB, 2020), NBFIs in EMEs were growing faster than NBFIs in advanced nations; their assets constituted an 11 % share of global NBFIs assets in 2019.
- The share of assets held by NBFIs sector (as a percentage of their total financial assets) in Brazil, China, India, and Russia increased from 2013 to 2019. IMF (2014) reported that in the case of advanced economies, the growth of NBFIs has been mainly due to the growth of sectors such as investment funds, bond funds and other entities.
- While in the case of EMEs, the continued growth was attributable to broker-dealer activities and finance companies. This faster growth of NBFIs in EMEs may be due to the fact that there is a huge chunk of the population not covered by the formal financial system in these economies that are catered to by entities such as NBFIs (Arora and Zhang, 2018), thus contributing to the growth of these economies.
- Albeit, their unchecked growth may expose the financial system to several instability risks, and therefore, the factors propelling this growth need to be examined to control the possible shadow banking risks.

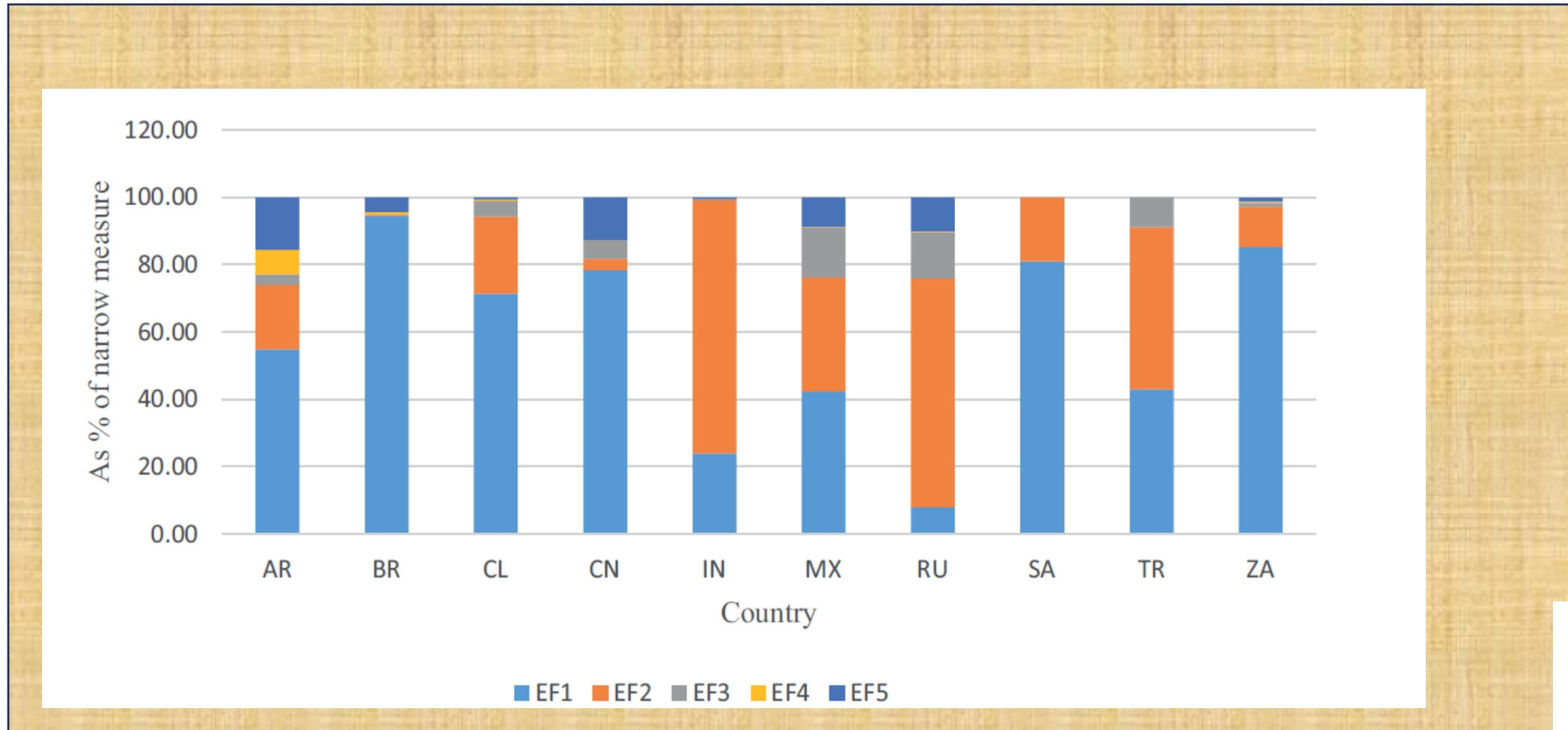
Growth in financial assets of banks and OFIs as a percentage of GDP in 11 EMEs.



Growth in financial assets of banks and OFIs as a percentage of GDP in 11 EMEs.

- ✓ This narrow measure is bifurcated into five economic functions (EF).
- ✓ EF1 refers to collective investment vehicles (CIVs) that might be exposed to risk related to runs.
- ✓ EF2 refers to entities that are dependent on short-term funding. It includes finance companies, leasing or factoring companies and consumer credit companies.
- ✓ EF3 refers to entities engaged in market intermediation dependent on short-term funding, such as broker-dealers.
- ✓ EF4 includes entities that facilitate credit creation, such as credit insurance companies, and
- ✓ EF5 includes entities engaged in securitization activities, such as structured finance vehicles.

Economic function classification (2019) (as a percentage of narrow measure of NBF1).



Put Option

A Put Option gives the buyer:

- ✓ the right, but *not the obligation*.
- ✓ to sell a specified asset to the seller (of Put option).
- ✓ at a pre-determined exercise price.
- ✓ on or before a fixed expiration date in the future.
- ✓ by paying the Put option premium or price, now
- On (or before) expiration date, the put buyer may choose to exercise the put option, wherein he would receive the exercise price and deliver the asset to the seller (of put option).
- Alternatively, he may choose not to exercise the put option, then the put option simply expires worthless.

Put Option

Today(Jan 1), the price of RIL stock is Rs. 60/-. The Put option on ABCL stock at different exercise prices with Expiration Date as April 15 are available as below.

Exercise Price	Put Price
55	0.95
60	1.20
65	1.70
70	3.10
75	5.20
80	7.95
85	11.50
90	15.20
95	16.25
100	17.40
105	18.65

You decide to buy a Put option with exercise price of Rs75/-for Rs. 5.20

Put Option

January 1

Pay Rs.5.20

April 15

If the stock price < Rs 75/- (say Rs 65/-):

You will like to exercise the Put Option

- Sell the stock for Rs 75/- (and Buy the stock immediately at Rs 65/-) ,
- Pay-off of Rs. 10/- (Rs 75 – Rs 65), &
- Profit of Rs. 4.80 (Rs 10 – Rs 5.20)

If the stock price > Rs 75/-,(say Rs 85/-)

You will not exercise the Put Option, and let the Put expire worthless.

- Pay-off of Rs. Zero/- &
- Loss of Rs. 5.20

Profit/(Loss) for Put Option Holder

2	Put Price on January 1			5.20	
3	Put Exercise Price(X)			75.00	
4					
5					
6	Stock Price on April 15	Cash Flow at t=0	Will Put Buyer exercise the Put?	Cash Flow at t=T	Total Profit/(Loss)
7	0	-5.20	Yes	75.00	69.80
8	60	-5.20	Yes	15.00	9.80
9	65	-5.20	Yes	10.00	4.80
10	70	-5.20	Yes	5.00	-0.20
11	75	-5.20	Indifferent	0.00	-5.20
12	80	-5.20	No	0.00	-5.20
13	85	-5.20	No	0.00	-5.20
14	90	-5.20	No	0.00	-5.20
15	95	-5.20	No	0.00	-5.20
16	100	-5.20	No	0.00	-5.20

ITM

ATM

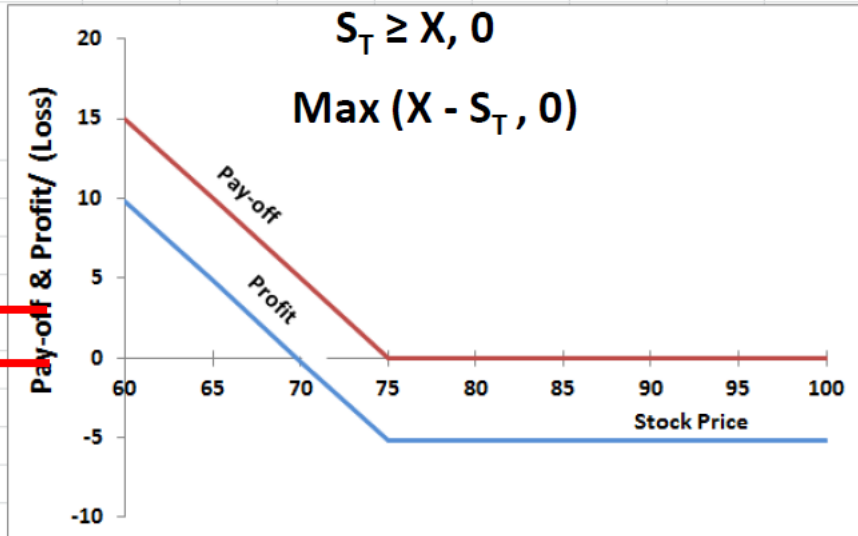
OTM

Pay-off:

$$\text{If } S_T < X, X - S_T$$

$$S_T \geq X, 0$$

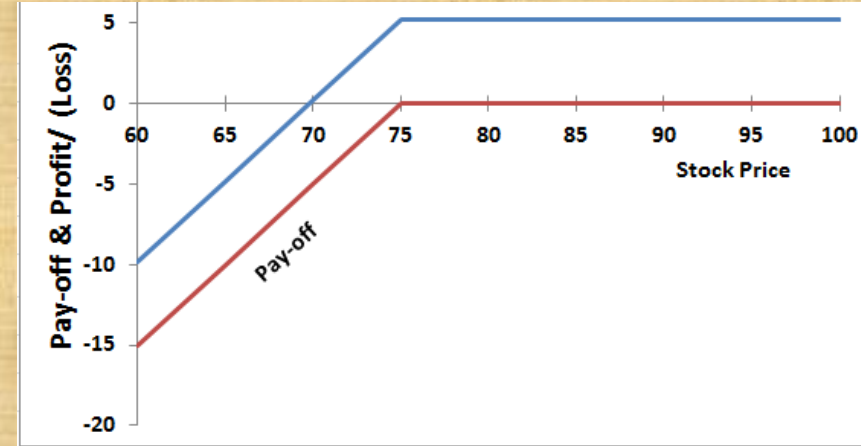
$$\text{Max}(X - S_T, 0)$$



- When you **Buy a Put Option**, you Buy the right to sell the stock in the future for a pre-determined price, for which you pay the Put premium today.

Profit/(Loss) for Put Option Writer

Stock Price on April 15	Cash Flow at t=0	Will Put Buyer exercise the Put?	Cash Flow at t=T	Total Profit/(Loss)
0	5.20	Yes	-75.00	-69.80
60	5.20	Yes	-15.00	-9.80
65	5.20	Yes	-10.00	-4.80
70	5.20	Yes	-5.00	0.20
75	5.20	Indifferent	0.00	5.20
80	5.20	No	0.00	5.20
85	5.20	No	0.00	5.20
90	5.20	No	0.00	5.20
95	5.20	No	0.00	5.20
100	5.20	No	0.00	5.20



Types of Options

Basic types:

- ✓ American Options can be exercised at anytime upto the Expiration date.
- ✓ European Options can be exercised only on the Expiration date.

Others:

- ✓ Bermudan Options can be exercised during a specified period only during the life of the option.
- ✓ Asian Options pay-off is based on the average price of the underlying asset during the life of the option.
- ✓ Barrier Options – pay off depends upon whether the price of the underlying asset reaches a specified level during the life of the option.

Options

- ✓ In both the cases (Call option and Put option), the buyer of the option pays the option premium to the seller (writer) of the option for selling the rights.
- ✓ The seller of the option is obligated to take the other side of the buyer's decision.
An options contract defines the **rights** of the **buyer** and the **obligations** of the **seller**.

Swaps

Literal meaning : “to exchange”

- Swap is a transaction which transforms one stream of future cash flows into another stream of future cash flows with different features.
- It is a combination of series of Forward Contracts.
- Does not involve legal swapping of actual debt but an agreement is made to meet certain cash flows.
- Basic types:
 - **Interest rate Swap**
 - Fixed to Floating Rate or Floating to Floating
 - **Currency Swap**
 - **Swaption: Option to enter into a Swap**

Linkage between Spot & Derivatives Market

- ✓ Arbitrage and the Law of One Price:
- ✓ Storage Mechanism
- ✓ Delivery & Settlement

Role of Derivatives Markets

Risk Management: Derivatives are used to reduce risks.

- *A wheat farmer sells his harvest (at the time of sowing itself) in the futures market thereby reducing the price risk, which he faces at the time of harvest.*

- Market participants who seek to reduce their risk are called **Hedgers**.

2. Speculation: Derivatives can serve as investment vehicles. Derivatives can provide away to make bets that are highly levered.

- *If a Speculator has information about possible upturn in a price, he may go long on the forward market instead of the cash market.*

- Market participants who seek to increase their risk are called **Speculators**.

Role of Derivatives Markets

3. **Price Discovery:** Forward and futures markets are an important source of information about prices. Futures price is a consensus reflecting the spot price of an asset in the future.
4. **Operational Advantages:**
 - Derivative markets entail lower transaction costs, hence makes them easier and attractive to use in lieu of spot markets.
 - Derivatives Markets are usually more liquid (as less investment is required).
 - Also allow for short selling of securities (not allowed in some spot markets)
5. **Market Efficiency:** Through the use of arbitrage, the market efficiency is improved further.

Regulators in India

- SEBI
- RBI

Adjustments for Corporate Actions (Stock Options)

Corporate actions like dividends, bonus shares or stock splits change the value of underlying stock and hence options of these stock would also change in value.

➤ Adjustment for Dividends: Exchange traded options do not provide for adjustment for dividends.

- For dividends upto 10% of the market value of underlying stock, no adjustment is made to no. of share or exercise price is made.
- For extra-ordinary dividends (above 10%), amount of dividend is reduced from the all the exercise prices on the stock (w.e.f. ex-dividend date)

Adjustments for Corporate Actions (Stock Options)

Adjustment for Bonus Shares (Stock Dividend) : Bonus shares do not change the aggregate value of shares but affects the stock price.

- For an 'a:b' bonus issue, No. of shares increase to $(1 + a/b)$ of its previous value and Exercise price goes down by $1 / (1 + a/b)$ of its previous value.

No. of Shares in 1 Options Contract 500 $(1 + \text{Bonus ratio})$

$$500 * (1 + 2/5) = 700$$

Exercise Price 140 $1 / (1 + \text{Bonus ratio})$ $140 * 1 / (1 + 2/5) = 100$

Closure of Options

For Buyer of an Option:

✓ By Exercising the Option

✓ By letting the Option to expire

• For Seller of an Option:

✓ By entering an offsetting trade

• An *obligation* to sell/buy stands nullified by a *right* to buy/sell and not by creating another obligation to buy/sell.

If Means To Nullify Sold Call Obligation to Sell → Buy Call

Sold Put Obligation to → Buy Put

Factors Affecting Option Prices

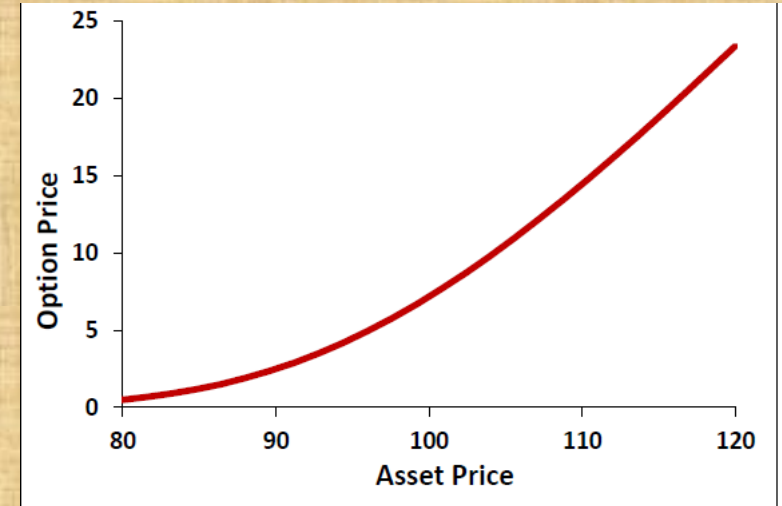
The following factors have a bearing on the price of a Stock Option:

1. Current Stock Price (S_0)
2. Strike Price (X)
3. Time to expiration (t)
4. Volatility of the Stock Price
5. Risk-free interest rate (r_f)
6. Dividends expected during the life of the option.

Stock Prices

Call Option:

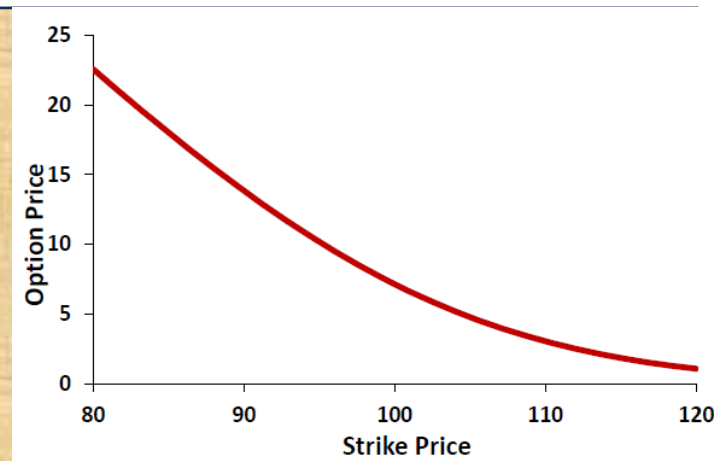
- Call option is exercised, if Stock Price(S) > Exercise Price(X).
- Hence, call option becomes more valuable, if the Stock Price (S) increases.



Exercise/Strike Price

Call Option:

- Again, call option is exercised, if Stock Price(S) > Exercise Price(X).
- So, for higher exercise prices, call option would become cheaper.

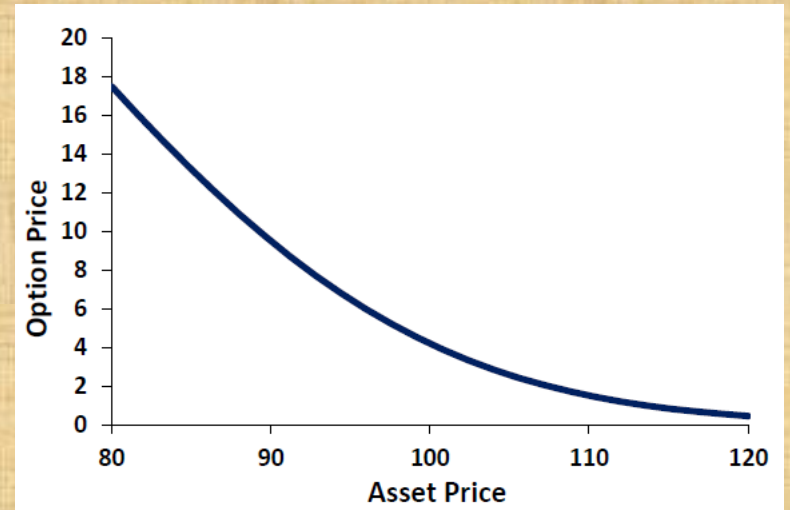


PUT Options

Put Option:

Put Option is exercised, if Exercise Price (X) > Stock Price (S).

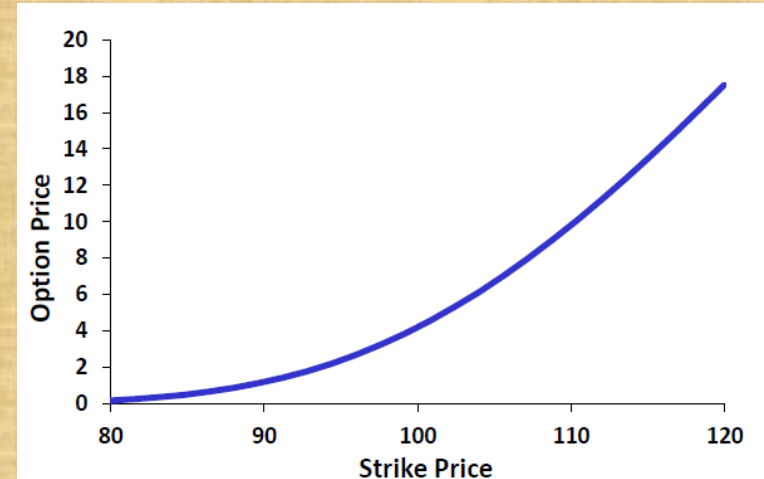
Put option becomes more valuable, if Stock Price (S) decreases.



PUT Option

Put Option:

- Put Option is exercised, if **Exercise Price (X) > Stock Price (S)**.
- Put option becomes more expensive for higher Exercise prices(X).



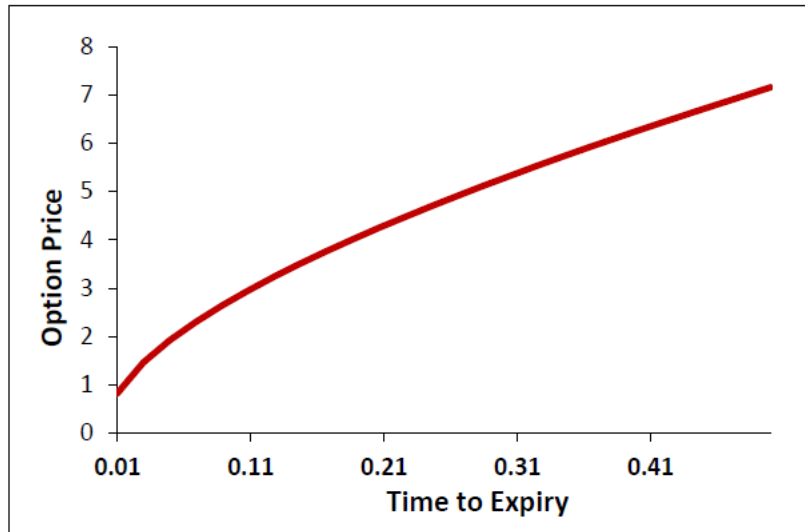
Time to Expiration

Consider two American Call/Put options which differ only in their time to expiration.

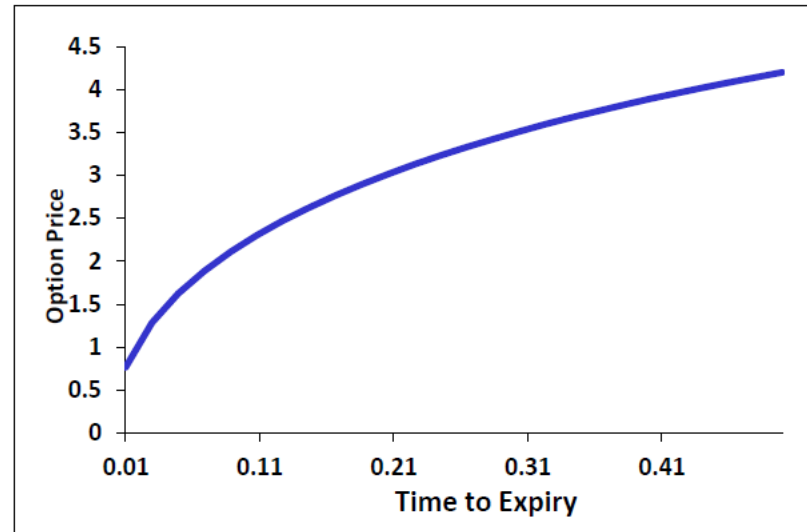
- Owner of the longer-life option not only has all the exercise opportunities as the shorter-life options, but also more.
- Hence, longer life American Options would be worth more than the shorter-life Options.
- **Usually**, European Call & put options also become more valuable as time to expiration increases.
- However, events in the intervening period, may reduce the value of a long-life option, thereby making it less valuable than a short-life option.

Time to Expiration

Call Option



Put Option



Volatility

Volatility means uncertainty about the prices of the underlying asset.

- Call option holder benefits from price increases but has a limited downside in case the stock price falls.
- Put option holder benefits from decreases in stock prices but have limited downside in case the prices increase.
- Hence, price of both, call & put options increases with increase in Volatility of the underlying asset.

Risk-free Interest Rate

- **Impact on Call Options:**

- By paying the Call premium now, a trader saves 'X' till maturity. So higher the interest rate, higher will be his savings.

- Hence, as r_f increases, Call will become more attractive.

- **Impact on Put Options:**

- When a trader sells the underlying asset (on exercise of put option) he receives 'X' in the future.

- So, the present value of 'X' would reduce, as interest rates increase.

- Hence, as r_f increases, Put will become less attractive.

Dividends

Dividends decrease the stock prices on ex-dividend date.

- Hence, call price decreases with dividends, and put price increases with dividends.

Summary

Impact of each factor on Option Price (keeping all other factors fixed)

Factors		Call Option	Put Option
Stock Price	↑	↑	↓
Strike Price	↑	↓	↑
Time to Expiration	↑	↑	↑
<i>(American Options)</i>			
Volatility	↑	↑	↑
Risk-free Interest Rate	↑	↑	↓
Dividends	↑	↓	↑

Put – Call Parity

Prices of European Put and Call options on the same underlying with identical exercise price and expiration dates have a special relationship.

- Consider the following portfolios:

- ✓ Portfolio A: One European Call Option and cash of Xe^{-rT}

$(C + Xe^{-rT})$

- ✓ Portfolio B: One European Put Option and One Share

$(P + S_0)$

What is the worth of each portfolio on expiration?

Put – Call Parity

Consider the stock of Reliable Industries which is currently trading at Rs.750/-, while the 3-month European call option on it is trading at Rs.67.50 for exercise price of Rs.745/-. If the risk-free interest rate is 6% pa, what should be the price of a put option on the same stock with the same exercise price and expiration date?

$S_0 = \text{Rs. } 750/-$ $CE = \text{Rs. } 67.50$; $X = \text{Rs. } 745/-$; $r_f = 6\% \text{ pa}$;

$PE = ?$

$CE + Xe^{-rT} = PE + S_0$

$67.50 + 745e^{-(0.06)3/12} = PE + 750$

$PE = 67.50 + 733.91 - 750.00 = \text{Rs. } 51.41$

Uses of Put – Call Parity

To check for arbitrage opportunities resulting from relative mispricing of Call and Put options.

- If $CE + Xe^{-rT} > PE + S_0$, then Portfolio 'A' is overvalued relative to Portfolio 'B'. Hence, sell the securities in Portfolio 'A' and buy securities in Portfolio 'B', and make arbitrage profits.
- If $CE + Xe^{-rT} < PE + S_0$, then Portfolio 'B' is overvalued relative to Portfolio 'A'. Hence, sell the securities in Portfolio 'B' and buy securities in Portfolio 'A', and make arbitrage profits.

Uses of Put – Call Parity

Consider a dividend paying stock trading at Rs.50/-. An ATM 1-month European call is available for Rs.3.50. If an ATM put option on the stock is trading at Rs.2.70, is there any arbitrage opportunity? (Assuming risk-free interest rate as 2% p.a)

Put -Call Parity

$S_0 = X = \text{Rs. } 50/-$; $C_E = \text{Rs. } 3.50$; $P_E = 2.70$; $r_f = 2\%$ pa (cc); $t = 1/12$ yrs

- Portfolio A: $C_E + Xe^{-rT} = 3.50 + 50e^{-(0.02)1/12} = 3.50 + 49.92 = 53.42$
- Portfolio B: $P_E + S_0 = 2.70 + 50 = 52.70$
- Portfolio A > Portfolio B.

➤ Today: Buy Put, Buy Stock, Sell Call and sell Bond (Borrow)

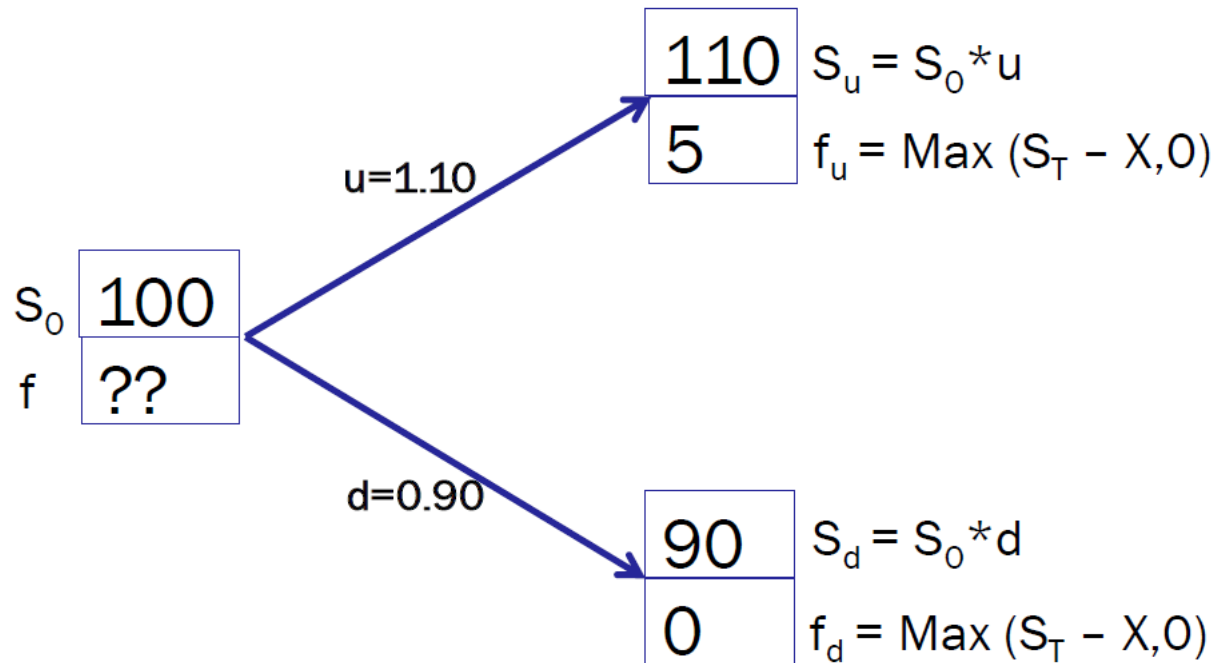
Cash Flow (at $t=0$): $-2.70 - 50.00 + 3.50 + 49.92 = 0.72$

➤ After 1-month:

If $S_T < X$	If $S_T > X$
1. Put : ITM : Sell the stock for $X = 50$	1. Put : OTM : No action
2. Call : OTM : No action	2. Call : ITM : Sell stock at $X = 50$
3. Stock: Deliver the Put option.	3. Stock: Deliver under Call option.
4. Borrowings: Repay with interest $49.92e^{(0.02)1/12} = 50$	4. Borrowings: Repay with interest $49.92e^{(0.02)1/12} = 50$
Net Cash Flow = $50 - 50 = \text{Nil}$	Net Cash Flow = $50 - 50 = \text{Nil}$

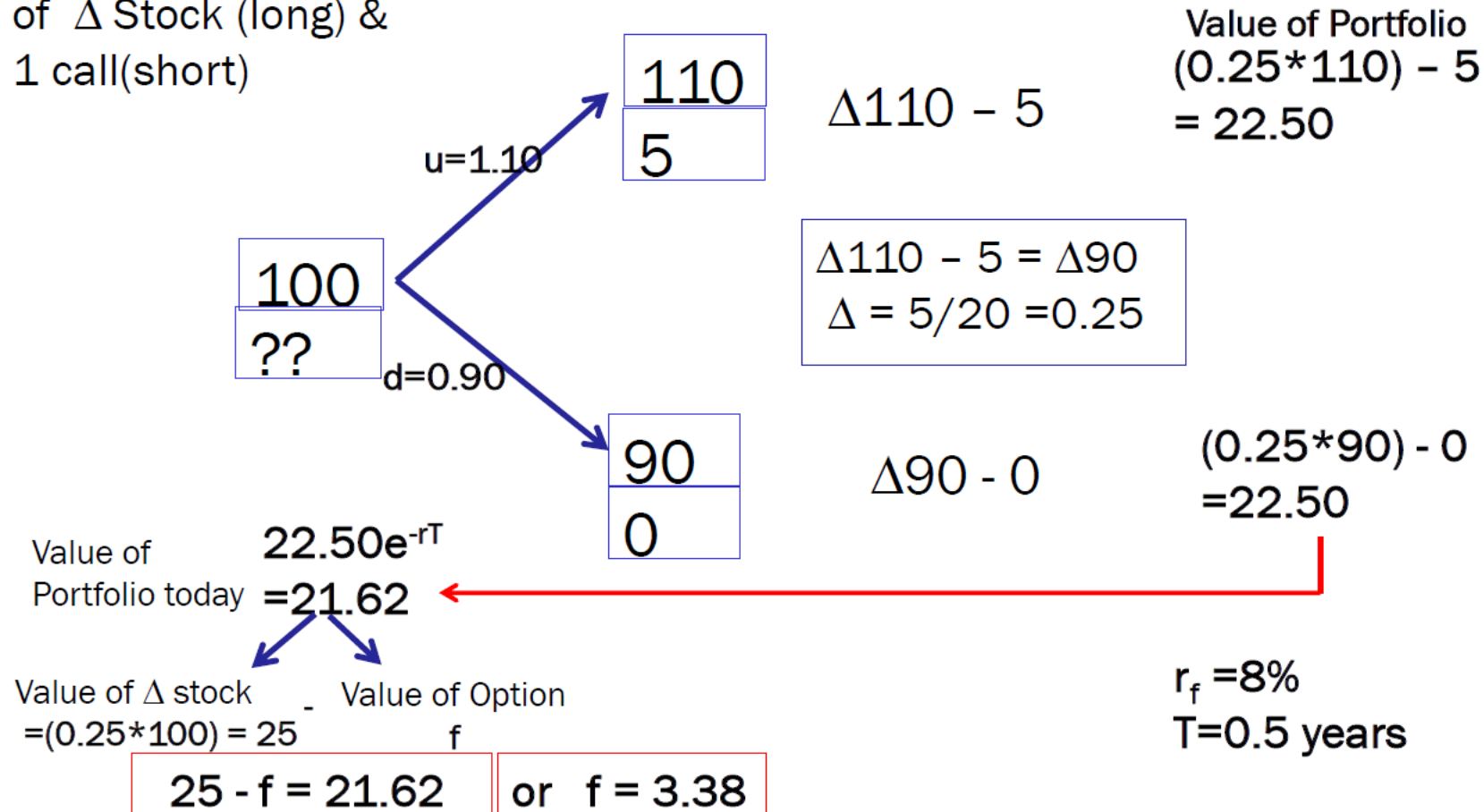
Binomial Option Pricing Model

$X = 105$



Binomial Option Pricing Model

Construct a risk-less portfolio
of Δ Stock (long) &
1 call(short)



Binomial Option Pricing Model

For No-arbitrage argument:

$$\Delta S_0 u - f_u = \Delta S_0 d - f_d$$

$$\Delta = \frac{f_u - f_d}{S_0 u - S_0 d}$$

$$\Delta = \frac{5 - 0}{110 - 90} = 0.25$$

Present value of the Portfolio = Cost of Portfolio at t=0

$$(\Delta S_0 u - f_u) e^{-rT} = \Delta S_0 - f$$

$$f = e^{-rT} \{ p f_u + (1-p) f_d \}$$

$$p = \frac{e^{rT} - d}{u - d}$$

Binomial Option Pricing Model

	I	J	K	L	M
1	In case the Call is Fairly Priced				
2		Nos.	Price		
3	Call sold	(1,000)	3.38	(3,382.24)	Liability
4	Stock bought	250	100.0	25,000.00	Asset
5				21,617.76	Amount to be invested
6					
7	If the Stock Goes UP				
8	Calls are exercised	(1,000)	5	(5,000.00)	
9	Stock	250	110	27,500.00	
10				22,500.00	
11	Rate of Return			8.00%	<-- =LN(L10/L5)/\$B\$4
12					
13	If the Stock Goes DOWN				
14	Calls are Not exercised	(1,000)	0	-	
15	Stock	250	90	22,500.00	
16				22,500.00	
17	Rate of Return			8.00%	<-- =LN(L16/L5)/\$B\$4
18					

Binomial Option Pricing Model

To find the price of Call option, using the above formula:

$$p = \frac{e^{rT} - d}{u - d} = \frac{e^{0.08*0.5} - 0.90}{1.10 - 0.90} = 0.70405$$

$$f = e^{-rT} \{ pf_u + (1-p)f_d \}$$

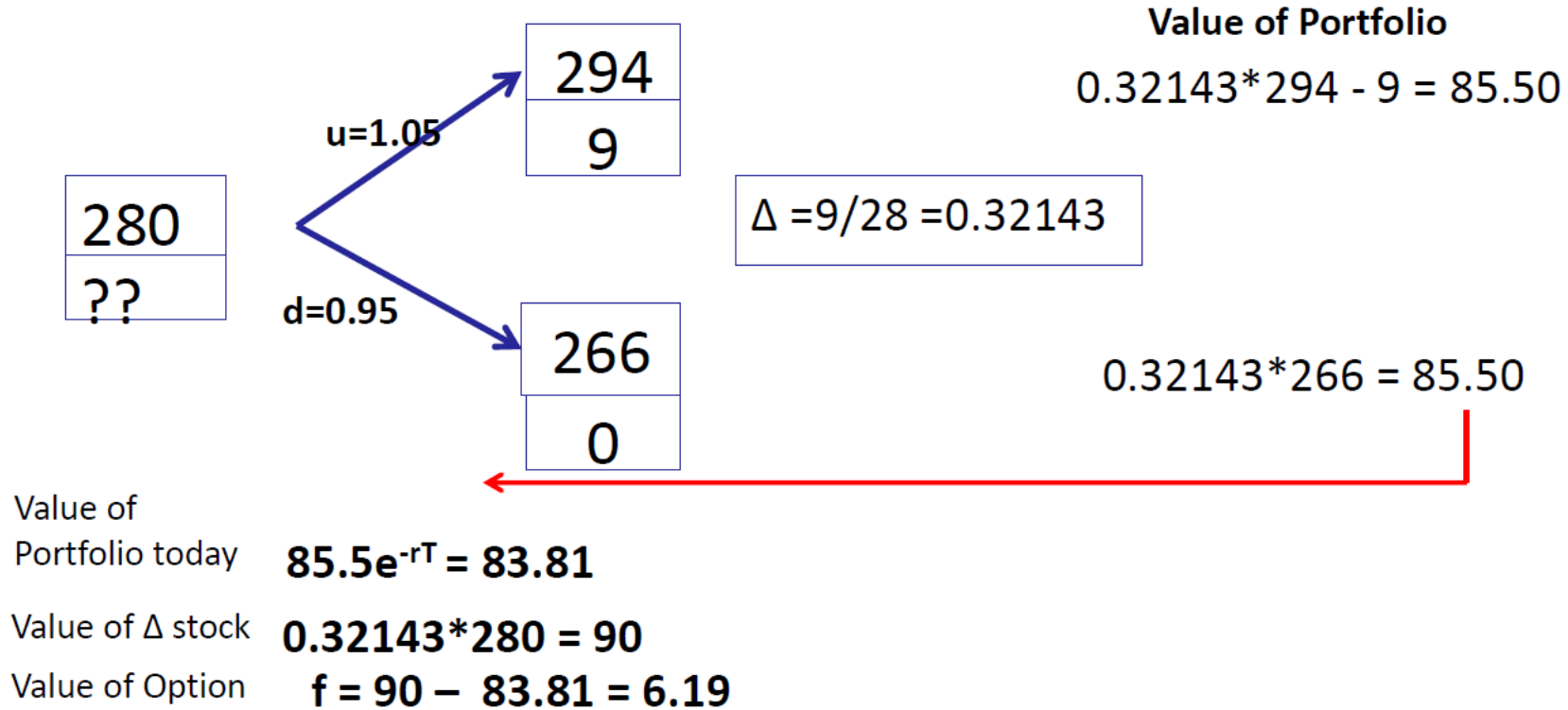
$$f = e^{-0.08*0.5} \{ 0.70405*5 + (1-0.70405)*0 \}$$

$$f = 3.38224 = \text{Rs.3.38}$$

Binomial Option Pricing Model

$S_0 = \text{Rs}280/-$; $X = \text{Rs. } 285/-$; $T = 3/12$ years; $u = 1.05$; $d = 0.95$; $r_f = 8\%$, Find the value of Call option, using 1 stage Binomial Pricing model.

Binomial Option Pricing Model



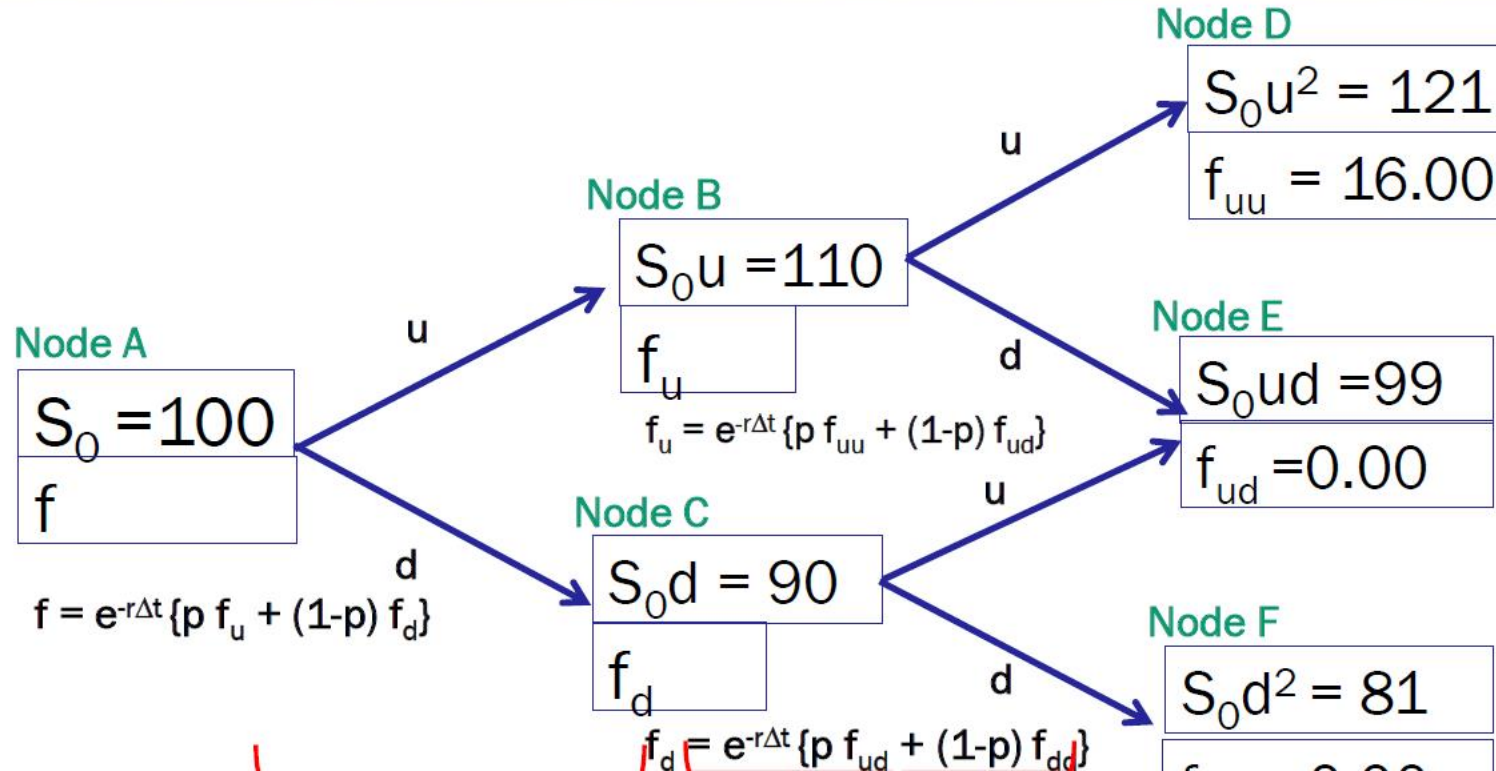
Binomial Option Pricing Model

To find the price of Call option, using the above formula:

$$p = \frac{e^{rT} - d}{u - d} = \frac{e^{0.08 \times 0.25} - 0.95}{1.05 - 0.95} = 0.70201$$

2 Stage European Call Option

$S_0 = \text{Rs } 100/-$; $X = \text{Rs. } 105/-$; $T = 0.5$ years ($\Delta t = 0.25$); $u = 1.10$; $d = 0.90$; $r_f = 8\%$, Find the value of Call option, using 2 stage Binomial Pricing model.



2 Stage European Call Option

$$p = \frac{e^{0.08*0.25} - 0.90}{1.10 - 0.90} = \frac{1.0202 - 0.90}{1.10 - 0.90} = 0.60101$$

Node B

$$f_u = e^{-r\Delta t} \{p f_{uu} + (1-p) f_{ud}\} \quad f_u = e^{-0.08*0.25} \{0.60101*16 + (1-0.60101)*0\}$$
$$f_u = 9.42575 = 9.43$$

Node C

$$f_d = e^{-r\Delta t} \{p f_{ud} + (1-p) f_{dd}\} \quad f_d = e^{-0.08*0.25} \{0.60101*0 + (1-0.60101)*0\}$$
$$f_d = 0.00$$

Node A

$$f = e^{-r\Delta t} \{p f_u + (1-p) f_d\} \quad f = e^{-0.08*0.25} \{0.60101*9.43 + (1-0.60101)*0\}$$
$$f = 5.55530 = 5.55$$

2 Stage European PUT Option

$$p = \frac{e^{0.08*0.25} - 0.90}{1.10 - 0.90} = \frac{1.0202 - 0.90}{1.10 - 0.90} = 0.60101$$

Node B

$$f_u = e^{-r\Delta t} \{p f_{uu} + (1-p) f_{ud}\} \quad f_u = e^{-0.08*0.25} \{0.60101*0 + (1-0.60101)*6\}$$
$$f_u = 2.34654 = 2.35$$

Node C

$$f_d = e^{-r\Delta t} \{p f_{ud} + (1-p) f_{dd}\} \quad f_d = e^{-0.08*0.25} \{0.60101*6 + (1-0.60101)*24\}$$
$$f_d = 12.92080 = 12.92$$

Node A

$$f = e^{-r\Delta t} \{p f_u + (1-p) f_d\} \quad f = e^{-0.08*0.25} \{0.60101*2.35 + (1-0.60101)*12.92\}$$
$$f = 6.43728 = 6.44$$

$$f = e^{-2r\Delta t} \{p^2 f_{uu} + 2p(1-p) f_{ud} + (1-p)^2 f_{dd}\}$$

$$f = e^{-2*0.08*0.25} \{(0.60101)^2*0 + 2(0.60101)(1-0.60101)*6 + (1-0.60101)^2*24\}$$
$$f = 6.43555 = 6.44$$

2 Stage European PUT Option

$$p = \frac{e^{0.08*0.25} - 0.90}{1.10 - 0.90} = \frac{1.0202 - 0.90}{1.10 - 0.90} = 0.60101$$

Node B

$$f_u = e^{-r\Delta t} \{p f_{uu} + (1-p) f_{ud}\} \quad f_u = e^{-0.08*0.25} \{0.60101*0 + (1-0.60101)*6\}$$
$$f_u = 2.34654 = 2.35$$

Node C

$$f_d = e^{-r\Delta t} \{p f_{ud} + (1-p) f_{dd}\} \quad f_d = e^{-0.08*0.25} \{0.60101*6 + (1-0.60101)*24\}$$
$$f_d = 12.92080 = 12.92$$

Node A

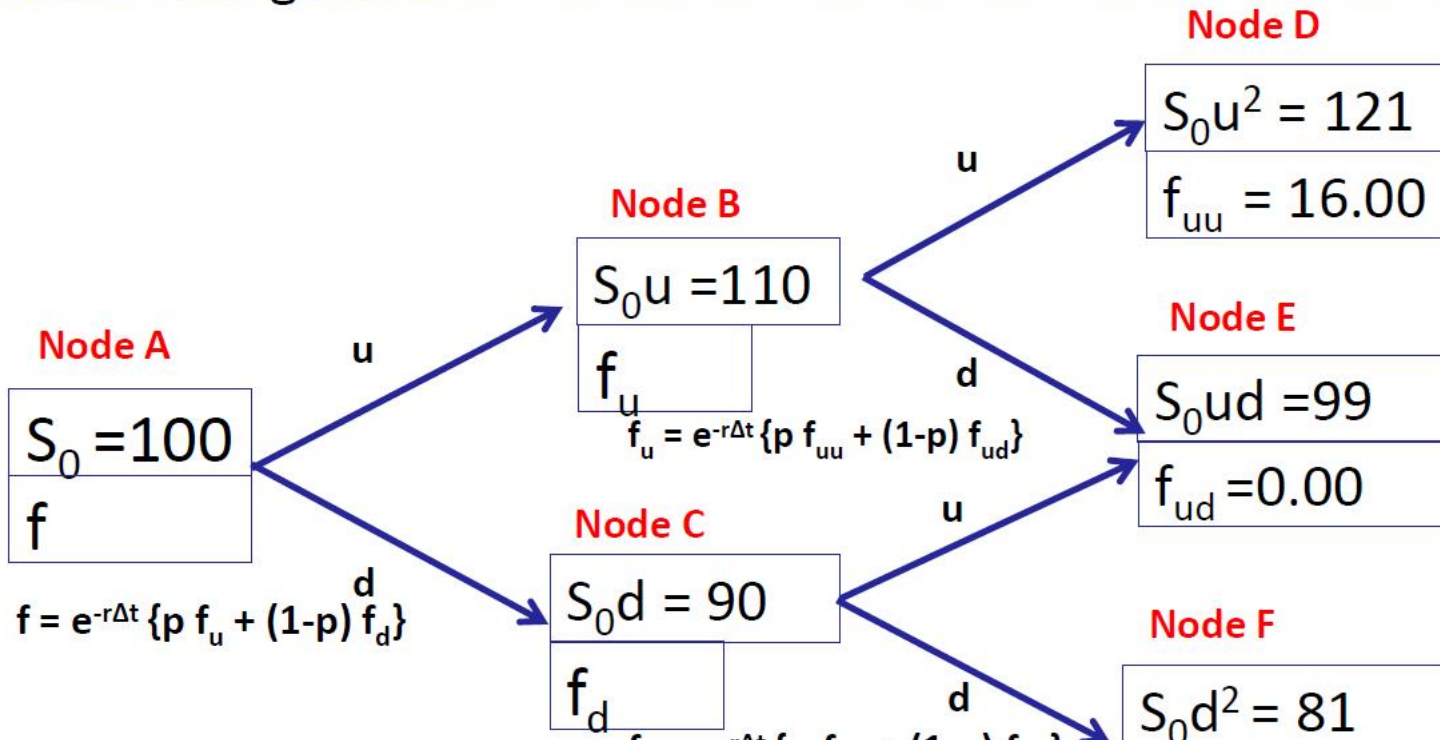
$$f = e^{-r\Delta t} \{p f_u + (1-p) f_d\} \quad f = e^{-0.08*0.25} \{0.60101*2.35 + (1-0.60101)*12.92\}$$
$$f = 6.43728 = 6.44$$

$$f = e^{-2r\Delta t} \{p^2 f_{uu} + 2p(1-p) f_{ud} + (1-p)^2 f_{dd}\}$$

$$f = e^{-2*0.08*0.25} \{(0.60101)^2*0 + 2(0.60101)(1-0.60101)*6 + (1-0.60101)^2*24\}$$
$$f = 6.43555 = 6.44$$

2 Stage American Call Option

$S_0 = \text{Rs } 100/-$; $X = \text{Rs. } 105/-$; $T = 0.5$ years ($\Delta t = 0.25$); $u = 1.10$;
 $d = 0.90$; $r_f = 8\%$, Find the value of American Call option, using 2 stage
 Binomial Pricing model.



2 Stage American Call Option

Node B

$$f_u = e^{-r\Delta t} \{p f_{uu} + (1-p) f_{ud}\} \quad f_u = e^{-0.08*0.25} \{0.60101*16 + (1-0.60101)*0\}$$
$$f_u = 9.42575 = \mathbf{9.43}$$
$$f_u = \text{Max}(S_t - X, 0) \quad f_u = \text{Max}(110 - 105, 0) = 5$$

Node C

$$f_d = e^{-r\Delta t} \{p f_{ud} + (1-p) f_{dd}\} \quad f_d = e^{-0.08*0.25} \{0.60101*0 + (1-0.60101)*0\}$$
$$f_d = \mathbf{0.00}$$
$$f_d = \text{Max}(S_t - X, 0) \quad f_d = \text{Max}(90 - 105, 0) = 0$$

Node A

$$f = e^{-r\Delta t} \{p f_u + (1-p) f_d\} \quad f = e^{-0.08*0.25} \{0.60101*9.43 + (1-0.60101)*0\}$$
$$f = 5.55530 = \mathbf{5.55}$$