



Trading the Bond Basis

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Investment Analytics



Bond Futures

■ CBOT Bond Futures Contract

- Based on notional 15 year T-Bond
- 8% Coupon
- Face Value \$100,000
- Deliverable Bond
 - Short can deliver any T-Bond with:
 - At least 15 year to maturity
 - Any coupon
- Conversion Factor
 - Translates price of notional 8% bond into equivalent price for deliverable securities



Conversion Factors

- Approximate clean price (decimal) which the bond would trade at if yielded 8% to first call
- Example (9-Jul-98):
 - 7 1/4% of Nov 2016
 - Quoted price 117 13/32
 - YTM 5.71%
 - Futures contract for delivery Sept 98
- Conversion factor = 0.9291
- Check: substitute quoted price as 92.91
- YTM is 8%

Conversion Factor Example

Bond		Bond Basis	
Face Value	100	Delivery	01-Sep-98
Quoted Price	92 28/32	Futures Price	125 27/32
Settlement	09-Jul-98	Repo Rate	4.50%
Maturity	15-Nov-16	Conversion Factor	0.9291
Remaining Term	6,704	Basis	-769/32
Coupon	7.250%	Forward Accrued Interest	2.1474
Accrued Interest	1.0836	Futures Invoice Price	119.0681
Invoice Price	93.9586	Futures Invoice Amount	\$119,068.08
Yield to Maturity	8.00%	Daily Carry (32's)	0.2546
Modified Duration	9.62	Implied Repo Rate	178.16%

Substitute Conversion Factor for Quoted Price gives YTM of 8%



Conversion Factor Formula

- C is bond coupon
- n is # whole years from first day of delivery month to maturity (or call)
- z is # months between n and maturity (call), rounded down to nearest quarter

$$F = \frac{1}{1.04^{v/6}} \left[\frac{C}{2} + d + \frac{C}{0.08} \times (1 - d) \right] - \left[\frac{C}{2} \times \frac{6 - v}{6} \right]$$

$$v = z \text{ if } z < 7; 3 \text{ if } z \geq 7$$

$$d = \frac{1}{1.04^{2n}} \text{ if } z < 7; \frac{1}{1.04^{2n+1}} \text{ otherwise}$$



Conversion Factor Characteristics

- Unique for each bond and delivery month
- > 1 if coupon $> 8\%$,
- < 1 if coupon $< 8\%$
- Get larger for bonds with coupons $< 8\%$ for successive contract months
- Get smaller for bonds with coupons $> 8\%$ for successive contract months
- Used to calculate the invoice price of bonds delivered into the CBOT futures contract



Bond Futures Prices

- $\text{Futures Price} = \text{Spot Price} + \text{Net Cost of Carry}$
- $\text{Net Cost of Carry} = \text{Funding Cost} - \text{Accrued Interest}$
 - If coupon interest $<$ funding cost, negative carry
 - If coupon interest $>$ funding cost, positive carry
 - Most of the time bond markets have positive carry due to upward sloping yield curve
 - *Implication:* Futures price $<$ cash price



Funding Cost

- Depends on the *repo rate* RP
- Funding Cost = $S \times (1 + RP \times n/360)$
 - n is number of days to delivery

Futures Price: Cost of Carry Formula

- $$[(FP \times CF) + FA] = (SP + SA) (1 + m/360 \times RP) - [k \times C\%/2(1 + RP \times n/360)]$$
- FP = Futures clean price
- FA = Accrued interest at forward delivery date
- SP = Clean price for spot settlement
- SA = Accrued interest at spot settlement date
- m = # days from spot settlement to forward delivery
- RP = Repo rate
- k = 0 if no coupons paid during holding period, 1 otherwise
- C% = Bond coupon rate
- n = # days from date of coupon to forward delivery date
- NOTE: assumes any coupon is reinvested at the repo rate



Futures Invoice Price

- The Long received bond
- Pays the Short *futures invoice price*
- Futures Invoice Price =
(Futures Price x CF) + Forward Accrued Interest
- Example: 7.25% of Nov 2016
 - Delivery 1-Sep-98
 - FIP = $125 \frac{27}{32} \times 0.9291 + 2.1474$
= 119.0681



Carry

- The difference between:
 - Coupon interest made by holding bond
 - Cost of financing the bond
- Positive in upward sloping yield curve
- Daily Carry
 - $\text{Daily Carry} = (\text{Daily Coupon Income} - \text{Daily Financing Cost})$
 - $\text{DCI} = (\text{Coupon}/2) \times 1/\text{days in coupon period}$
 - $\text{DFC} = \text{Invoice price} \times \text{Repo Rate} \times 1/360$



Carry Example

- 7 1/4% of 2016
 - Invoice price = 118.4898
 - Repo rate = 4.5%
 - Daily coupon income = $(7.25/2) \times 1/184 = \0.019701
 - Daily financing cost = $118.4898 \times 0.045 / 360 = \0.014811
- Daily Carry = $\$0.019701 - \$0.014811 = \$0.00489$
- Daily carry in 32nds
 - Each 1/32 is worth $\$0.0003125$
 - So daily carry in 32 is $\$0.00665 / \$0.0003125 = 16/32$



Implied Repo Rate

- Rate of return from:
 - Buying cash bond
 - Sell futures
 - Deliver the cash bond against futures
- Solve Cost of Carry Formula:

$$(SP + SA)[1 + IRR(m/360)] = FIP + k \times C / 2 \times [1 + IRR(n/360)]$$



Implied Repo Rate

- Where no coupon payment:
 - $IRR = [FIP / (SP+SA) - 1] \times 360 / n$
- Example: 7.25% of 2016
 - $FIP = 119.0681$
 - $SIP = SP+SA = 118.4898$
 - $IRR = [119.0681 / 118.4898 - 1] \times 360 / 54$
 - $IRR = 3.25\%$



The Basis

- Difference between spot bond price and adjusted futures price:
- $B = SP - (FP \times CF)$
 - B is basis
 - SP is spot price of bond (clean)
 - FP is futures contract price (clean)
 - CF is conversion factor



The Basis - Example

- Basis = Quoted Price Cash Bond -
(Futures Price x Conversion Factor)
- Example
 - 7 1/4% of Nov 2016
 - Quoted price 117 13/32
 - Futures price (Sept) = 125 27/32
 - Conversion Factor = 0.9291
- Basis = 117 13/32 - (125 27/32 x 0.9291)
= 16/32



Trading the Basis

- Buy (go long) the Basis
 - Buy cash bond, sell equivalent futures
- Sell (short) the Basis
 - Sell cash bond, buy equivalent futures
- Trading mechanism
 - Leg into trade
 - Trade the basis on the EFP
 - Exchange of futures for physicals
 - Avoids execution risk of legging into trade



Sources of Profit in Basis Trading

- Two sources of profit:
 - Change in the basis
 - Carry
- Long Basis position
 - Profits from increase in basis
 - Earns carry (if carry is +ve)
- Short Basis position
 - Profits from decrease in basis
 - Loses carry (if carry is + ve)



How the Basis Behaves

- Basis fluctuates from day to day
- Causes:
 - Uncertainty over short term financing costs
 - Choice of deliverable bond
 - Maybe 20 or 30 deliverable bonds
 - Each bond has its own basis, carry, yield, implied repo rate
 - Timing of delivery
 - Delivery can be on any business day in delivery month



Cheapest to Deliver

- CTD bond is one which will lock in highest profit (lowest loss) when purchased against a short futures position
- CTD bond has the *highest implied repo rate*
- Recall that (assuming no coupon):
 - $IRR = [FIP / (SP + SA) - 1] \times 360 / n$
 - So CTD bond is bond which has the highest ratio of futures invoice price to spot purchase price



Futures Price and CTD

- Futures contract behaves as if it was a contract written on the CTD bond
- $(FP \times CF_{CTD}) + FA = (SP_{CTD} + SA_{CTD}) \times (1 + R \times n / 360)$

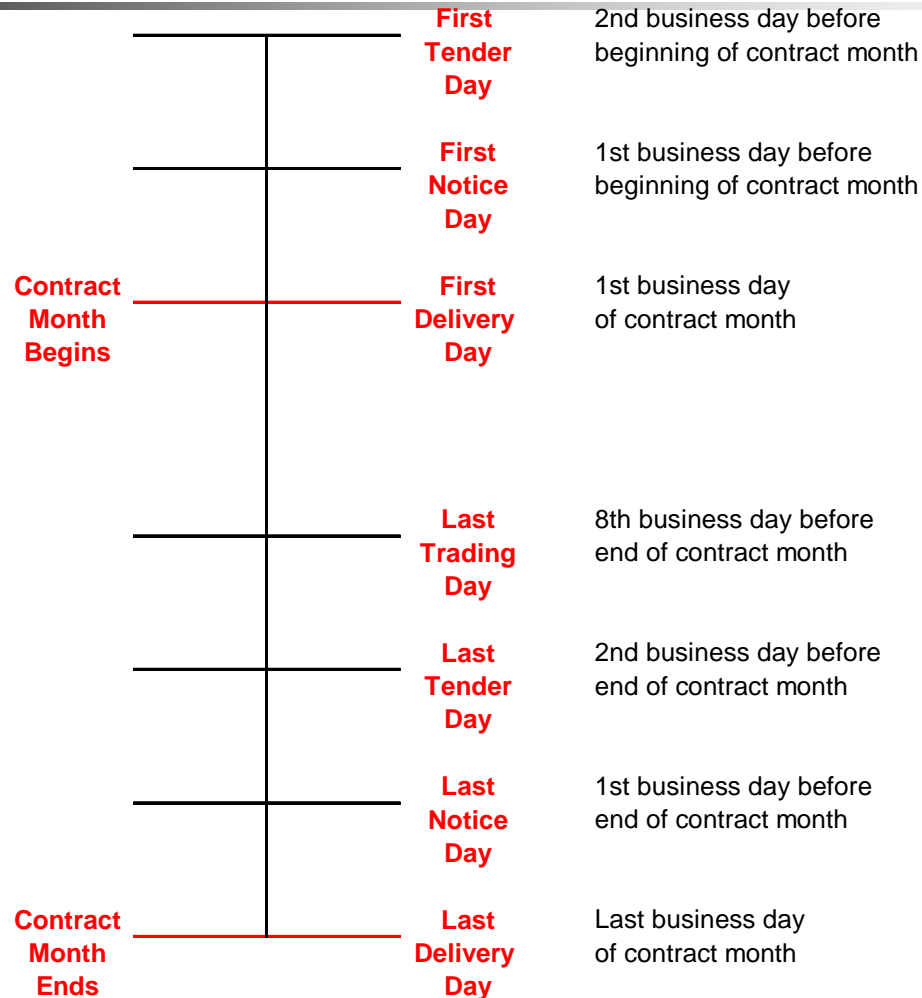


The Delivery Process

Tender (Position) Day	7:20 a.m.	Futures Market opens
	2.00 p.m.	Futures Market closes
	8.00 p.m.	Deadline for short to give delivery notice
Notice (Intention) Day	8:30 a.m.	Deadline for advising long
	2.00 p.m.	Deadline for short to nominate bond to be delivered
	3.00 p.m.	Deadline for long to give bank information to short
Delivery Day	10:00 a.m.	Deadline for short to deliver bond to clearing member's bank
	1.00 p.m.	Deadline for short's clearing member to deliver bond and for long to pay for bond



The Delivery Month





Timing of Delivery

- Positively sloped yield curve
 - Short (i.e. short futures) earns positive carry
 - Usually optimal to retain delivery options
 - Hence choose latest delivery day
- Negatively sloped yield curve
 - Short pays carry, motivated to delivery early
 - Conflicts with desire to preserve options
 - Repo rate has to be substantially higher than long term bond yield to justify early delivery
 - Typically, deliveries occur throughout month



Factors Affecting Cheapest to Deliver

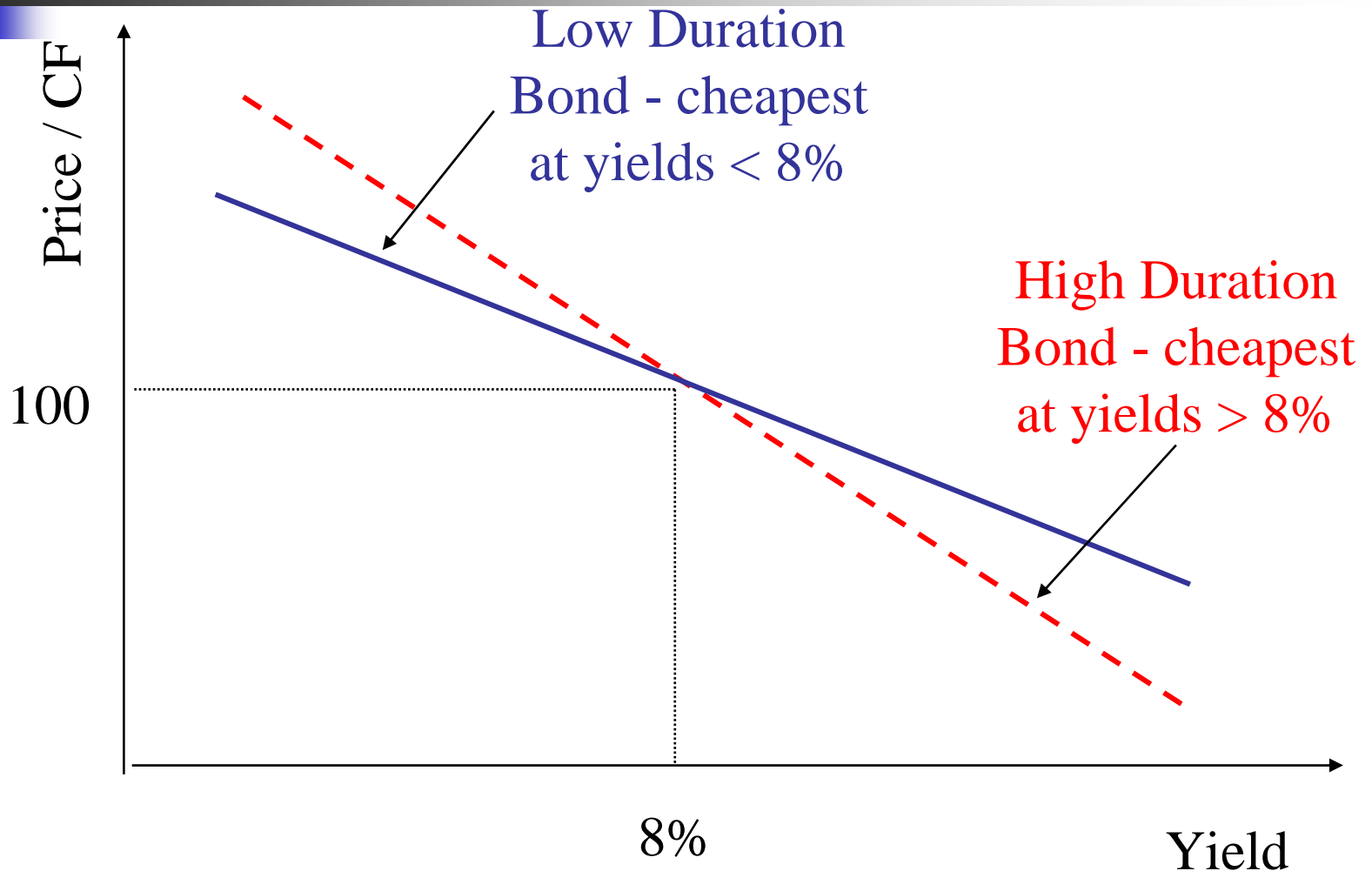
- Duration

- For bonds trading at same yield below 8%, lowest duration bond will be CTD
- For bonds trading at same yield above 8%, highest duration bond will be CTD

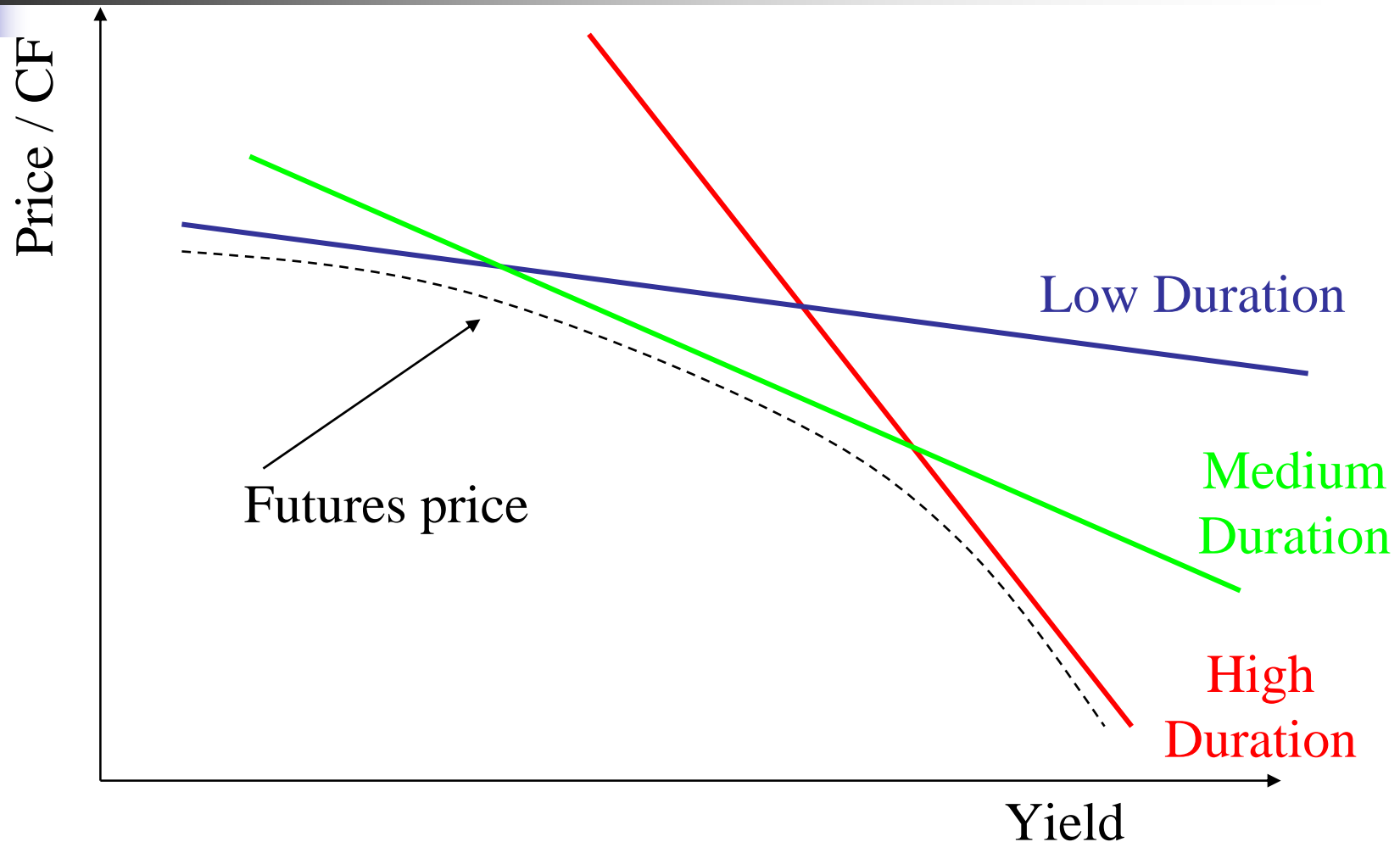
- Yield

- For bonds with same duration, bond with highest yield will be CTD

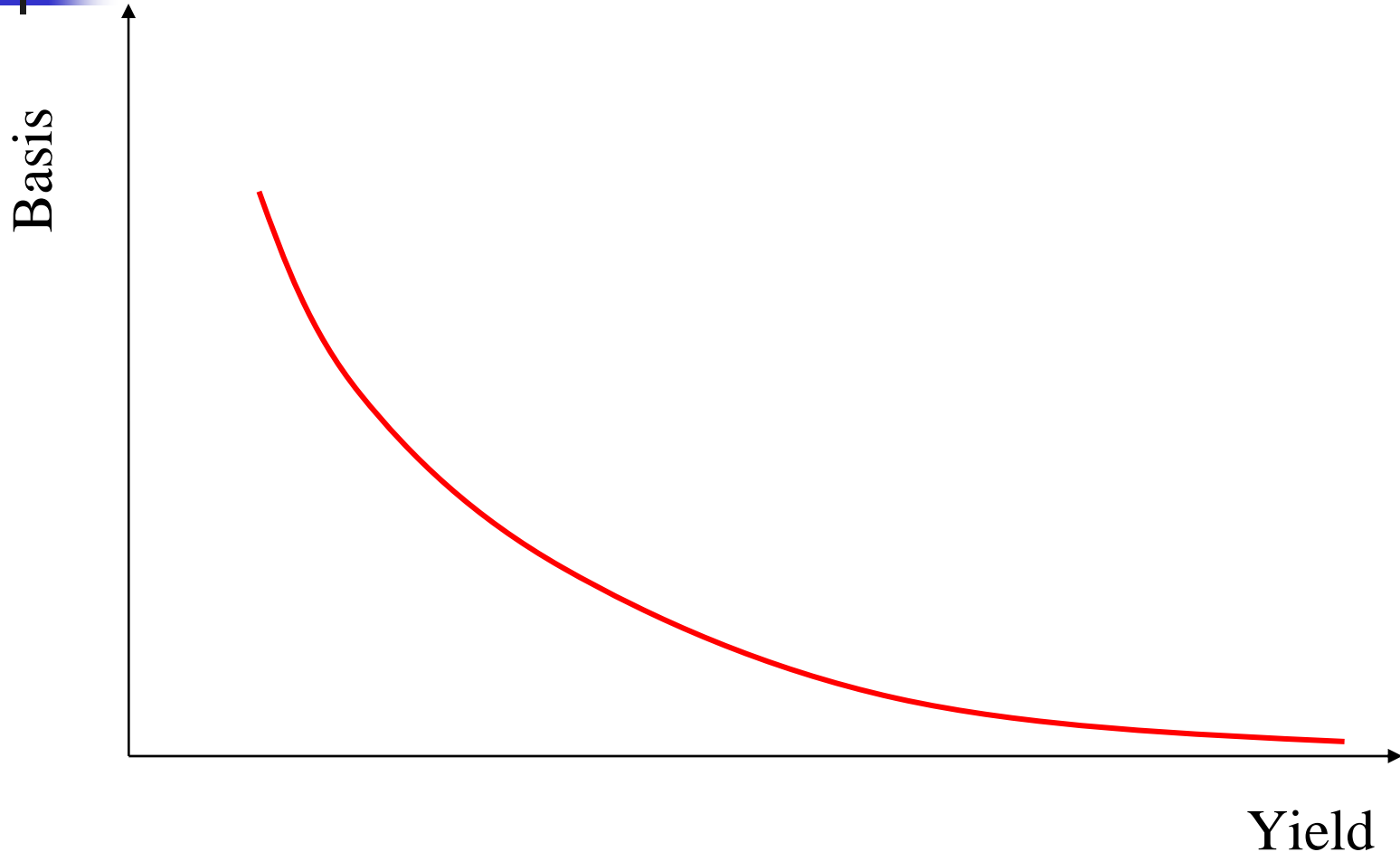
Duration and the Cheapest to Deliver



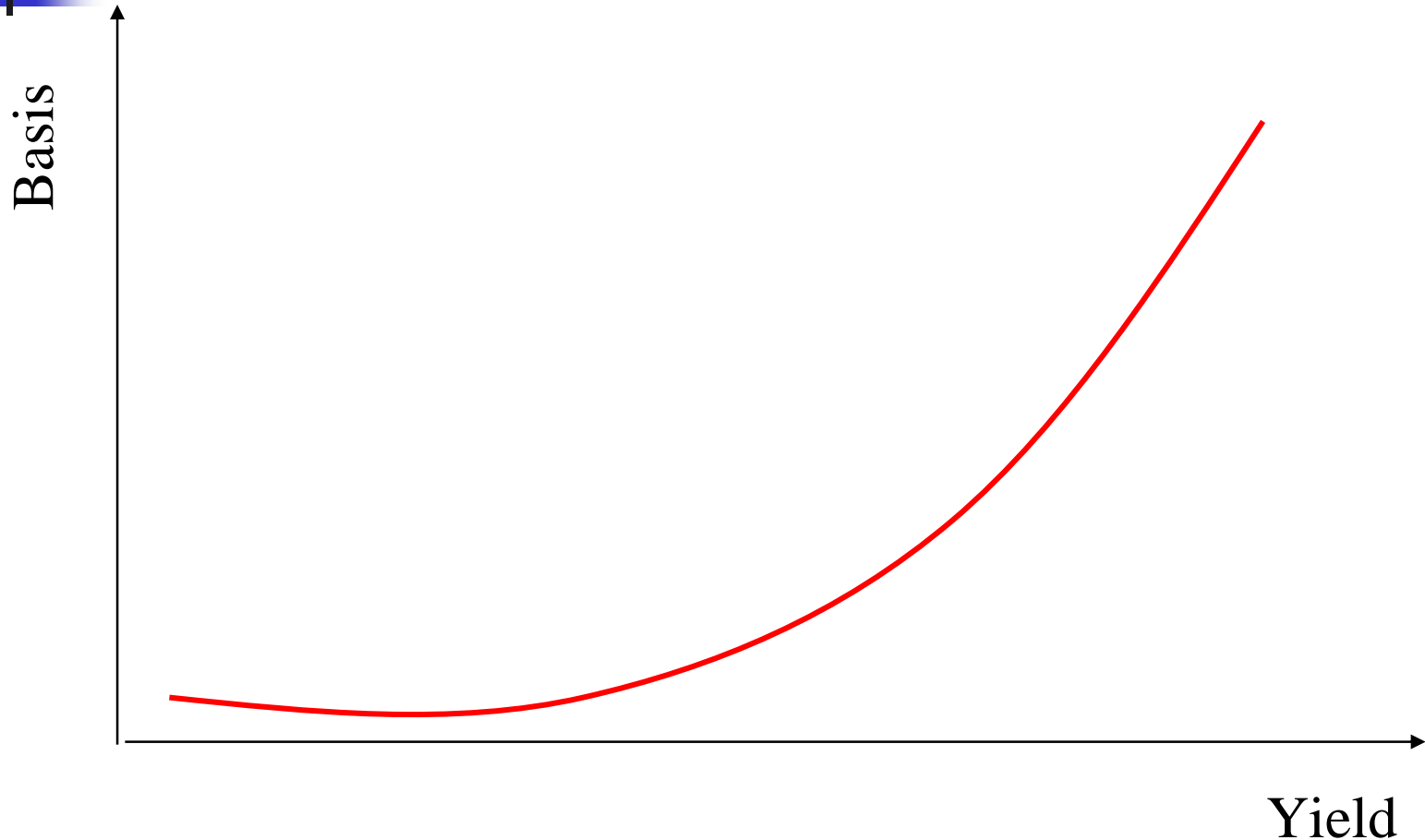
Futures Price Tracks Cheapest to Deliver



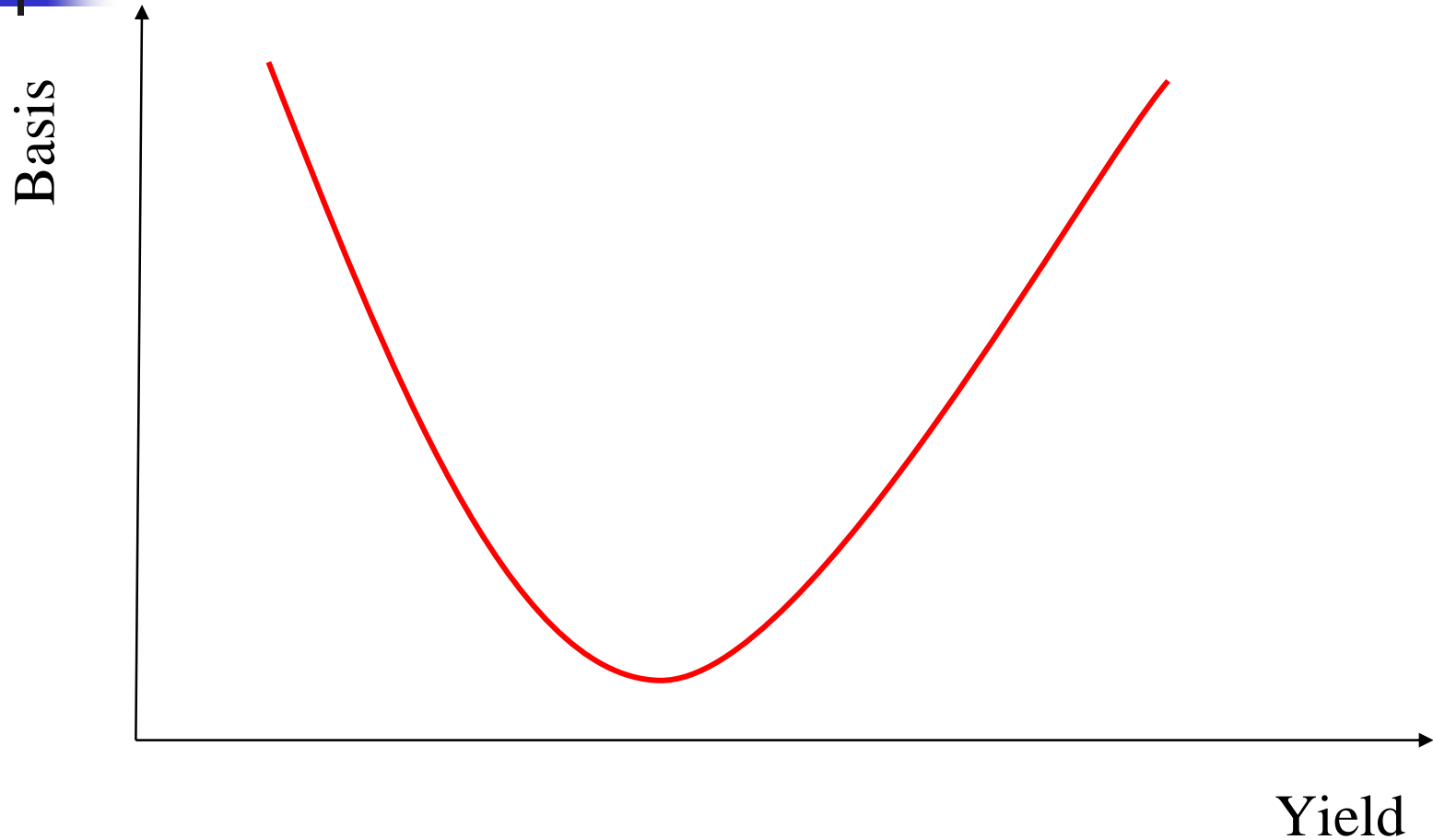
Basis of a High Duration Bond - like a call option on a bond



Basis of a Low Duration Bond - like a put option on a bond



Basis of a Medium Duration Bond - like a straddle





The Short's Delivery Options

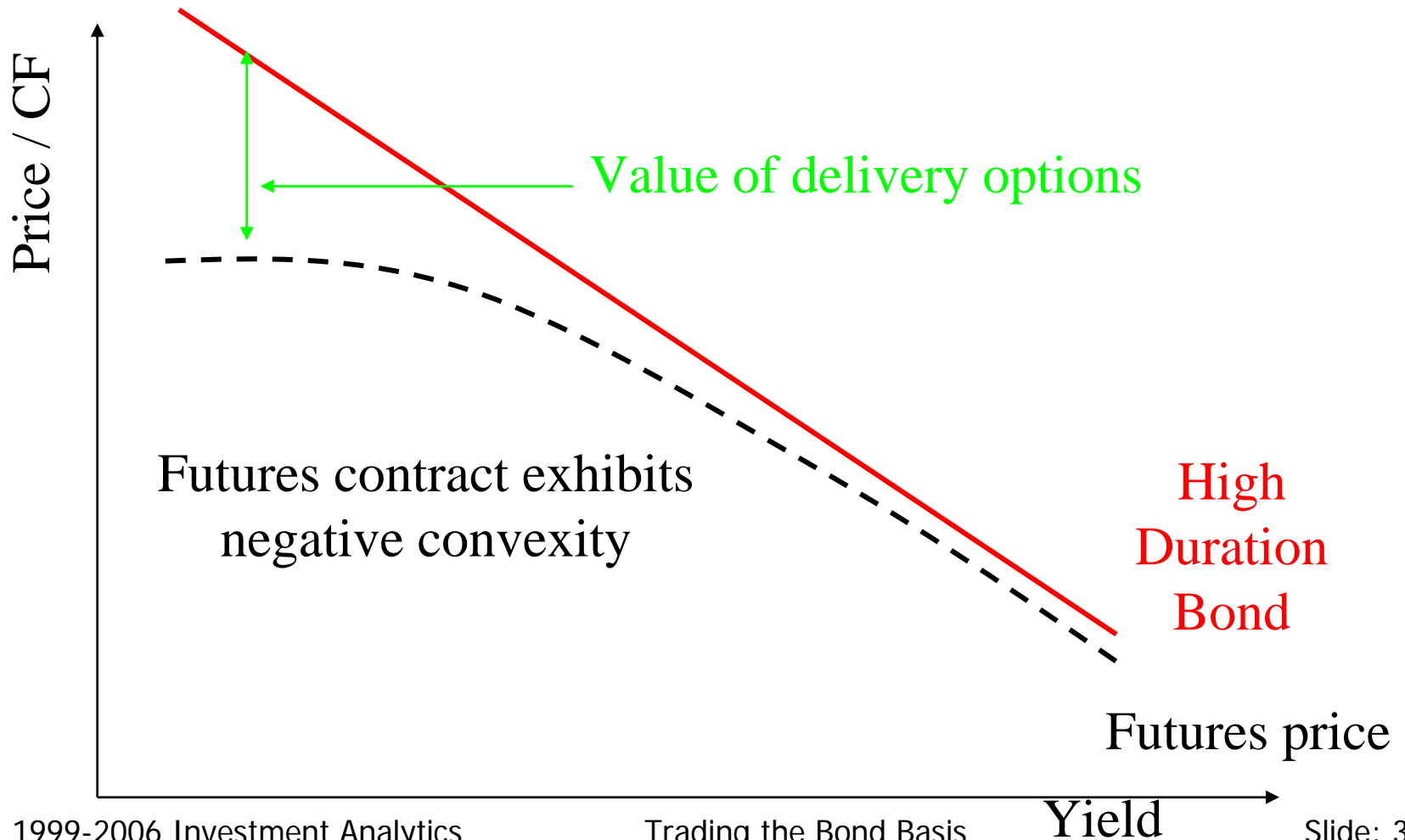
- Short enjoys *delivery options*:
 - Ability to select cheapest to deliver
 - Timing of delivery
- Quality Option
 - Options that can be exercised before close of trading
- Switch Option
 - Options that can be exercised between expiration of trading and last delivery day



The Quality Option

- Yield Levels
 - Causes changes in CTD
- Yield Spreads
- New Issues

Futures Contract & Convexity





Futures Pricing & Delivery Options

- Futures price < Forward Price of CTD
 - Difference is value of delivery options
- Futures price shows negative convexity
 - *Price Compression* due to rising value of delivery options as yields fall or increase substantially
 - Like price compression effect for a callable bond



Yield Spread

- Short has option to substitute one issue for another for delivery against the futures
 - Like a call option on a yield spread between the two issues
- Option value depends on yield volatility
 - Volatility greatest for shorter term yields
 - Hence yield spread option of greatest significance for 5-year and 10-year note basis trading



New Issues

- Timing, maturity, call features of new issue quite predictable, coupon unpredictable
- If yields are high
 - Issue is likely to have high coupon
 - Means lower duration
 - Hence unlikely to be CTD
- If yields are low
 - Issue likely to have low coupon
 - Means higher duration
 - Again, unlikely to be CTD
- Also, On-the-Run issues tend to trade rich



The Switch Option

- After futures contract expires:
 - Settlement price is fixed
 - Cash prices continue to fluctuate
 - Hence CTD may change between expiry and settlement
 - Known as the *switch option*

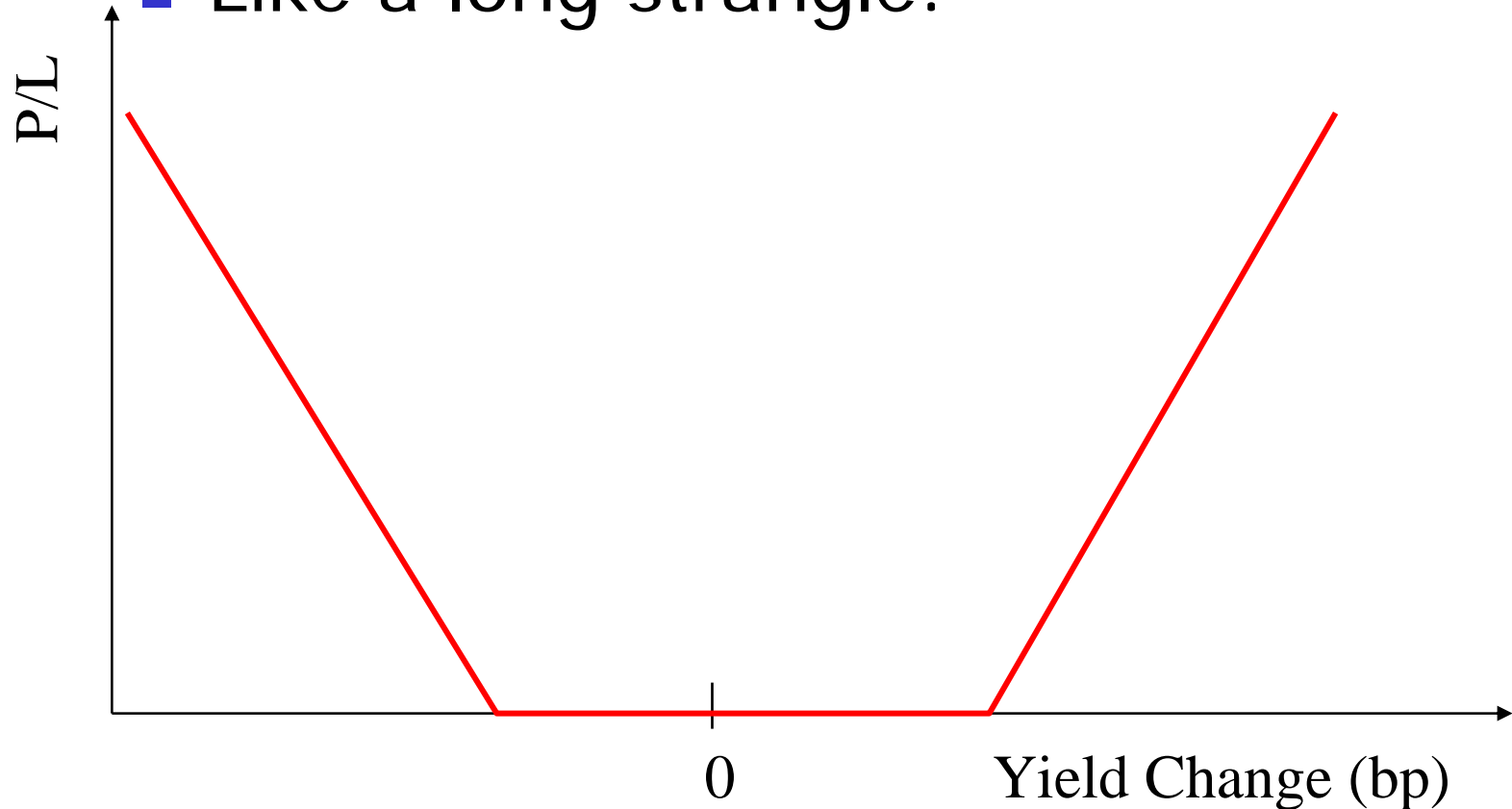


Cost of Switch Option

- Net cost of delivering eligible bond:
 - Net cost = Cash Price - (Factor x Final Futures Settlement Price) - Carry
 - Net Cost = Basis - Carry

Switch Option Payoff

- Like a long strangle:





Timing Options

■ Carry

- Mostly pays the short to deliver at end of delivery month
 - Earning positive carry on the trade
 - Hence value of option to deliver early is usually minimal

■ Wildcard Option

- Deadline for giving notice of delivery occurs after futures market closes
- Possible gains if cash market declines after close of futures market
- Again, option value is usually marginal



Wildcard Option - Example

- Trader is long \$1MM of CTD
 - Price 147.5939, CF = 1.5
 - Short 15 Futures, priced at 98.0938 at close
 - Cash bond price falls by 2 pts after futures close
- Alternative 1: wait for tomorrow's open
 - Futures price should fall by 2 / 1.5
 - Gain of approx \$20,000 on 15 short futures
- Alternative 2: buy \$0.5M par value of CTD and give notice of immediate delivery
 - Gain = $15 \times (147.1407 - 145.5938) \times \$1,000 = \$23,200$
 - Wildcard option is worth approx \$3,000



Valuing the Options

- Step 1 - Simulate yield distributions
 - Yield levels and yield spreads
- Step 2 - Calculate expected Basis Net of Carry
 - This gives estimated value of quality options
- Step 3 - Value switch option
 - Work out CTD's basis net of carry for each scenario
- Step 4 - Calculate Theoretical Futures Price
 - Theoretical Basis = Net Carry + Option Value
 - Theoretical Futures Price =
(Bond Price - Theoretical Basis) / CF



Option-Adjusted Basis

- Actual Basis = $SP - (FP \times CF)$
- Theoretical Basis = Net carry + Option Value
- Option-Adjusted Basis =
(Actual Basis - Theoretical Basis)
- Measures whether futures are rich or cheap
 - If $OAB = 0$, futures are fairly priced
 - If $OAB > 0$,
 - Delivery options are overpriced
 - Futures priced too low



Basis Trading Strategies

- Selling rich bases
- Selling basis of non-cheap bonds
- Buying cheap bases
- Calendar spreads
- Volatility trading



Selling Rich Bases

- During 1980's bond futures very cheap
 - Made 100's of basis points shorting the basis
- End 1980's
 - Bond futures fairly priced
- 1990's
 - 5 and 10-year note futures traded cheap
- Two strategy variants
 - Selling CTD
 - Selling another non-cheap (rich) bond



Shorting the CTD

- Like a short position in OTM option
- Capture premium (time value) as basis decays to zero
 - Premium = Basis Net of Carry
 - Typically 2/32 to 14/32
- If CTD is replaced by another bond, you lose:
 - Options you have sold go into money
 - Basis widens, unlimited loss potential
 - Caused by changes in yield level, spreads



Selling Basis of a Non-Cheap Bond

- Similar strategy, but basis will converge to some positive number
- Often sell on-the-run issues
 - More liquid
 - Often trades at a premium to off-the-run yields



Buying the Basis

- Like purchasing an option
- Long basis can be bullish, bearish or market neutral strategy
 - High duration bond basis = bond call
 - Low duration bond basis = bond put
 - Middle duration bond basis = bond straddle
- Option premium = Basis Net of Carry
- Seasonal Effects
 - Basis was consistently cheap towards month-end through early 1990's



Calendar Spreads

- Futures fair value =
$$\frac{(\text{CTD Price} - \text{Basis Fair Value})}{CF_{\text{CTD}}}$$
- Spread Trades
 - Buy one futures contract month, sell another
 - Subject to yield curve risk
- Buying the Spread
 - Buy near month, sell far month contract
 - Take delivery on lead contract at maturity
 - Now own cheap long basis position



Volatility Arbitrage

■ Bond Options

- Traded OTC and CBT
- Price paid for bond yield volatility determined by *implied volatility* on the options

■ Bond Futures

- Trading synthetic options
- Different estimate of yield volatility

■ Arbitrage Trading

- Compute OAB for each bond
- If $OAB > 0$, basis is rich
- Short basis, hedge by purchasing bond option



Summary - Basis Trading

- Basis
 - Difference between spot price and adjusted futures price
- Buying the basis is like owning bond option
 - Type of option depends on bond duration
- Option price
 - Basis Net of Carry
- Trading
 - Rich-Cheap trades triggered by OAB
 - Arbitraging volatility between options and futures markets