**Derivatives & Risk Management**

- Interest-rate derivatives
  - FRA’s & T-Bill futures
  - Swaps
    » Hedging International Financing Transactions
    » All-In Cost of Capital Computations
- T-Bond & T-Note futures
  - This lecture

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**Part III: Interest Rate Derivatives**

**Interest-Rate Derivatives (Recap. slide)**

- Forward rate agreements (FRA)
  - OTC contract; users "lock in" implied forward rate
- Interest Rate Futures (IRF) and T-Bill Futures
  - exchange traded futures contracts
  - underlying: 90-day interest rate (*contrast with FRA*)
- Interest-rate Swaps
  - OTC contract; converts exposure: fixed ↔ floating
  - Bundle of "time against time+6months" FRA’s
- Government bonds futures
  - Exchange-traded futures on a long-term government bond
T-Bond & T-Note Futures: Outline

- Bond quotes
  - money-market instruments
  - T-notes & T-bonds
  - corporate & municipal bonds
- T-Bond & T-Note futures
  - Pricing
  - Conversion factor
  - Options, including wild card

Bond Prices and Yield Quotes

- Money-market instruments
  - zero-coupon bonds
  - quotes vs. actual yields
- Long-term bonds
  - quotes
    - US government T-notes & T-bonds
    - corporate & municipal bonds
  - accrued interest

Long Term Bond Prices & Yield Quotes

- US government
  - T-Notes (< 10 years) vs. T-Bonds (10 to 30 years)
  - denominations (> $1,000), coupons (semi-annual)
  - bonds may be callable (typically last 5 years)
  - prices
    - quoted bond prices
      - (percentage + 32nds of 1%) of face value
    - accrued interest
      - \[ \frac{n}{N} \] = \frac{\text{actual # of days}}{\text{actual # of days in ref. period}}
      - example: March 1 to July 7 \( \Rightarrow n = 124 \text{ days} \)
Long Term Bond Prices & Yield Quotes 2

- Corporate & Municipal Bonds *(NOT Exam Material)*
  - denominations (> $1,000), coupons (semi-annual)
  - bonds may be *callable* (or, more rarely, *puttable*)
  - prices
    - quoted bond prices
      - munis: *(% + 8/ths %)* of face value
      - corporates *(decimal)*: *(% + 100/ths %)* of face value
      - accrued interest
        - 30/360 (vs. T-bonds: convention = actual/actual)
        - example: March 1 to July 7 = 4*30+2=122 days

T-Bond & T-Note Futures

- Contracts available *(CBOT; Hall, Table 6.1)*
  - T-bond futures
  - 2-year, 5-year, 10-year T-note futures
  - M-J-S-D cycle
- Long party
  - pays: quoted futures price *times* conversion factor + accrued interest
  (for each $100 of quoted face value)
- Short party
  - may deliver any bond – with some restrictions

T-Bond & T-Note Futures 2

- Options for short party
  - 1. bond to deliver
    - range of bonds can be delivered
    - dealt with by:
      - limit in bonds that can be delivered
      - conversion factor (varies with bond delivered)
  - 2. timing
    - timing sequence and futures contract trading
  - 3. wild card
    - closing times: bond market’s vs. futures market’s
T-Bond & T-Note Futures 3

• 1. Delivery option

<table>
<thead>
<tr>
<th>Futures contract</th>
<th>Time to maturity (from 1st day of delivery month)</th>
<th>Face value</th>
<th>Price quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-bond</td>
<td>10 - 14 years not callable for 15 yrs</td>
<td>$200,000</td>
<td>-</td>
</tr>
<tr>
<td>10-year T-note</td>
<td>15 yrs (10+6.5 yrs not callable for 6.5 yrs)</td>
<td>$100,000</td>
<td>-</td>
</tr>
<tr>
<td>5-year T-note</td>
<td>5-25 yrs (10+4.16 yrs)</td>
<td>$100,000</td>
<td>-</td>
</tr>
<tr>
<td>2-year T-note</td>
<td>5-25 yrs (10+1.91 yrs)</td>
<td>$200,000</td>
<td>-</td>
</tr>
</tbody>
</table>

T-Bond & T-Note Futures 4

• Conversion factor
  • why?
    » short party has large range of bond choices
    » so the playing field must be “ leveled”
  • what?
    » commit short party to deliver “nominal” 6% T-bond
    (used to be 8% before March 2000; still 6% despite...)
  • how?
    » adjust bond price (to be paid by long party)
    » as if its annual YTM were 6% (3% semi-annual)
    » on 1st day of delivery month
  • in practice
    » CME Group (prev. CBOT) builds comprehensive tables

T-Bond & T-Note Futures 5

• Computing conversion factors
  – A. Simplification #1
    • what?
      » bond maturity and times to coupon payment date
      » are rounded off to closest (i.e., earliest) 3 months
    • examples
      » bond has 20 years and 2 months to maturity
        → assume bond has 20 years to go
      » first coupon is to be paid in 4 months
        → assume coupons start in 3 months
T-Bond & T-Note Futures 6

- Computing conversion factors
  - B. Simplification #2
    - I. bond has exact # of half years after rounding off
      - > assume 1st coupon is paid in 6 months
      - > assume other coupons are paid every 6 months thereafter
        - example: bond w/20 years & 56 days left, 10% coupon
          \[
          P = QP = \sum_{n=1}^{20} \frac{\$5}{(1 + 0.03)^n} + \frac{\$100}{(1 + 0.03)^{20}} = \$146.23
          \]
        - conversion factor = \[
        \frac{P}{\text{par}} = \frac{\$146.23}{\$100} = 1.4623
        \]

T-Bond & T-Note Futures 7

- Computing the conversion factors
  - B. Simplification #2 (continued)
    - II. bond doesn’t have exact # of half years after rounding off
      - means there must be an extra 3-month period
      - > assume 1st coupon is paid in 3 months
      - > assume other coupons are paid every 6 months thereafter
        - example: bond w/18 years & 96 days left, 8% coupon
          \[
          QP = \frac{1}{(1 + 0.03)^3} \left( \sum_{n=4}^{18} \frac{\$4}{(1 + 0.03)^n} + \frac{\$100}{(1 + 0.03)^{18}} \right) = \$123.99
          \]

T-Bond & T-Note Futures 8

- Computing the conversion factor
  - B. Simplification #2 (continued)
    - II. (continued)
      - > still need to take accrued interest into account
        - accrued interests would be paid at bond purchase
        - so no discounting of those
          \[
          P = QP - \text{accrued int qrest} = \$123.99 - \frac{\$4}{2} = \$121.99
          \]
        - conversion factor = \[
        \frac{P}{\text{par}} = \frac{\$121.99}{\$100} = 1.2199
        \]
T-Bond & T-Note Futures 9

- Cheapest-to-deliver bond
  - Long party
    - Must take delivery of bond chosen by short party
    - Worth: bond price + accrued interest
  - Short party
    - Short party can deliver any bond
    - Hence, it will buy the cheapest one on the market
    - That meets the requirements of the exchange
  - Thus, must be bond for which:
    - Futures QP times conversion factor - bond QP is highest

T-Bond & T-Note Futures 10

- Cheapest-to-deliver bond: example
  - Futures price: current quote = 93:08
  - There are 3 deliverable bonds, with QP and CF:
    - #1 QP=99:16 CF=1.0382
    - #2 QP=143:16 CF=1.5188
    - #3 QP=119:24 CF=1.2615
  - Cheapest to deliver? Compute the cost of delivering
    - $ loss for short = cost of buying bond spot - proceeds from long
      - #1: 99.50 - (93.25 x 1.0382) = $2.69
      - #2: 143.50 - (93.25 x 1.5188) = $1.87 (smallest loss)
      - #3: 119.75 - (93.25 x 1.2615) = $2.12

T-Bond & T-Note Futures 12

- 2. Timing option
  - 3-day delivery sequence
    - Short can initiate any bus. day in delivery month minus 2 days
    - Day 1 (position day)
      - Short informs clearing house of intent to deliver
    - Day 2 (notice of intention day)
      - Clearing corp. matches oldest long to delivering short
      - Short invoices long
    - Day 3 (delivery day)
      - Short delivers to long
      - Long pays
      - Title passes (long has all ownership rights & liabilities)
T-Bond & T-Note Futures 13

2. Timing Option (continued)

- last day of trading
  - deliverable contract stops trading
  - 7th business day before last business day
  - of delivery month
- settlement
  - in that period, all positions must be settled by delivery
  - but short position still chooses when to deliver
- value
  - short party may wait for cash prices to drop
  - so the option is valuable & reflected in futures price

T-Bond & T-Note Futures 11

3. Wild Card option

- differences in closing time
  - futures stop trading on CBOT at 2PM, CST
  - intent to deliver by 8PM, CST
  - T-bonds stop trading after 2PM CST (4PM EST)
- option for short party
  - can exploit decreases in cash prices & cheapest bond
  - by deciding to deliver after trading on futures ends
- consequences for option pricing
  - theory
  - practice: assume all is known and use F-S parity

T-Bond & T-Note Futures 14

T-bond futures pricing (NOT Exam Material)

- theory
  - options need to be priced
  - tools to do see: Options
- if options were worthless
  - assume all is known
  - use forward-spot parity (F = PV of future cash-flows)
  - \[ F_0 = (B_0 - I) e^{rT} \]
  - or \[ F_{T-t} = (B_{T-t}) e^{r(T-t)} \]
### T-Bond & T-Note Futures 15

- **Quotes & Marking to Market**
  - example: go long 1(one) T-bond futures at open

<table>
<thead>
<tr>
<th>Time</th>
<th>Futures Price</th>
<th>Margin Requirement</th>
<th>Periodic Cash Flow</th>
<th>Cumulative Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-11-02 (Morning)</td>
<td>$103,750</td>
<td>$2,700(a)</td>
<td>-$2,700</td>
<td>-$2,700</td>
</tr>
<tr>
<td>01-11-02 (Close)</td>
<td>$102,988.75</td>
<td></td>
<td>-$781.25</td>
<td>-$3,481.25</td>
</tr>
<tr>
<td>01-15-02 (Close)</td>
<td>$104,750</td>
<td></td>
<td>-$1,781.25</td>
<td>-$5,262.50</td>
</tr>
<tr>
<td>01-18-02 (Close)</td>
<td>$102,750</td>
<td></td>
<td>-$2,000</td>
<td>-$7,262.50</td>
</tr>
<tr>
<td>01-22-02 (Close)</td>
<td>$103,750</td>
<td>+ $1,000</td>
<td>-$2,700</td>
<td>-$9,962.50</td>
</tr>
<tr>
<td>Then offset at $103,750</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Initial margin (Maintenance = $2,000)