FINANCING IN INTERNATIONAL MARKETS

2. BOND PRICING

Pricing Bonds: Brief Review

• Price of a Bond
The price of a bond ($P$) is determined by computing the NPV of all future cash flows generated by the bond discounted at an appropriate interest rate — i.e., the yield-to-maturity, or YTM.

$$P = \frac{C_1}{(1+YTM)} + \frac{C_2}{(1+YTM)^2} + \frac{C_3}{(1+YTM)^3} + ... + \frac{C_T}{(1+YTM)^T}$$

$C_t =$ Cash flows the bond pays at time $t$. ($C_T = \text{coupon}_T + \text{Face Value}_T$)

There is a one-to-one relation between $P$ and the YTM of a bond:
⇒ once you know the YTM, you know $P$ — given that you know the $C_i$’s.
Example: A straight Eurodollar bond matures in 1 year.
C = 10%
FV₁ = USD 100

1) P = USD 95 \( \Rightarrow \) YTM = ?

\[
P = \frac{C + FV_1}{(1 + YTM)} \Rightarrow 95 = \frac{110}{1 + YTM}.
\]
\[\Rightarrow YTM = \frac{110}{95} - 1 \Rightarrow YTM = .1578947\]

2) YTM = .1578947 \( \Rightarrow \) P = ?

\[\Rightarrow P = \frac{110}{1.1578947} = 95.\]

• Terminology
  – P = 100 (or 100% or 1) \( \Rightarrow \) “par” or “face value.”
    \[\Rightarrow \text{Simple mathematical fact: } P = 100 \Rightarrow YTM = C.\]
  – 100 bps = 1%

• YTM
The YTM is determined by:

\[YTM = \text{Base Rate } (k_f) + \text{Spread } (\text{Risk of Company})\]

\[k_f = r_f = \text{risk free rate} = \text{government bond (of similar maturity)}\]

\[\text{Spread} = \text{Risk of company} = \text{what the investment bank has to determine } (\text{in bps})\]

In general, the spread is related to credit risk –or risk rating (say, S&P, Moody’s). If a company is in a given risk category, there is a corresponding risk spread.

• Huang & Huang (2013): Corporate bond spreads are unusually high, given the low probability of default (“credit spread puzzle”).

Other factors influencing the bond spread: liquidity (50% of bond spread?) and size of issue (price pressure or price impact)
• **Technical detail**

Straight Eurobonds pay annual coupons. Adjustments need to be made if YTM are not expressed in per annum (p.a.) terms.

Suppose a company offers a bond with a 6-mo (s.a.) YTM = 7.365%. Then, we transform the s.a. YTM into p.a. (annual) YTM:

\[ \text{YTM}_{ST} = (1 + 0.07365/2)^2 - 1 = 7.501\% \text{ p.a.} \]

If in addition, the bond sells at par at inception –i.e., \( P=100 \)–, then,

\[ C_{ST} = \text{YTM} = 7.50\% \]

• **Bonds: YTM and Prices Move A Lot (Like any other financial asset)**

**Example:** 4.5% October 2020 Morocco EUR Eurobond

As expected, there is an inverse relation.
Pricing and Selection of a New Eurobond Issue

• Pricing a bond issue is one of the functions of an issuing house.

• Same domestic pricing techniques and models.
  Pricing mistakes in new bond issues are common:
  - Tight competition has led to underpricing (market share)
  - Issues sometimes are too complex.
  - Poor distribution.
  - Weak market conditions.

The process of pricing a Eurobond involves:
(1) Collection of information
(2) Evaluation of information

• **Information**
  **Borrowing Requirements**
  – Amount to be raised over a certain period.
  – Currency of exposure.
  – Maturity range
  – Call options
  – Target cost of funds.

**Preliminary Analysis of the Issue**
Guide to pricing a new issue:
(1) Assessment of the borrower's outstanding issues.
(2) Benchmark issues ("spread").
Market Conditions
Place an issue in relation to what is going on in the relevant markets:
– Bond Markets (International and Domestic)
– Derivative Markets
– Swap Markets

Perception of the Issuer
For issuers with outstanding issues: check price on the secondary market.
Caution: An issue maybe trading poorly because of bad design (i.e., small size), and not because of a negative perception.

For first-time issuer: A study of the perception of the issuer may cover:
– Perception of the borrower by its competitors.
– Relative perception of the issuer within its domestic market
– Perception of the borrower, if any, in the Euromarkets.

• Evaluation
• Sometimes, pricing looks like informed guesswork.

• In established markets, however, pricing proposals tend to converge.

• Benchmarking is the key.
Case Study I: Merotex

Pricing a New Straight Bond: Merotex

The Borrower
- Merotex is a leading construction firm, based in Gorizia, Italy.
- Merotex has recently bought two U.S. construction companies.
- Financed by bank loans: USD 250 million

Borrowing requirements
- Amount: **USD 250 million**
- Currency of exposure: **USD**
- Maturity: Merotex wants to refinance with *medium-term* USD debt.
- Preference: *Simple straight bond* with no early call options.

• Information

**Market conditions:**
- Good for a USD Eurobond issue.
- U.S. economic conditions are above expectations
- USD is currently very strong.
- Recent successful placement of 10-year Euro-USD issue by Fica.

**Merotex's Perception:**
- Merotex has issued GBP Eurobonds: obtained best terms.
- Merotex has no outstanding Euro-USD issues.
• Perception of similar international borrowers
(1) Comenti: Italian construction company
   - Comenti has several Eurodollar issues.
   - Last issue has 6 years of remaining life.
   - Currently trading at 40 bps over 6-yr U.S. Treasuries.
   - Comenti enjoys an excellent reputation in Euromarkets

(2) Fix Constructions (FC): major U.S. competitor in Florida.
   - FC has launched a 10-yr Eurodollar issue five years ago.
   - It has a call option two years from now.
   - Currently trading at a 65 bps over 5-year U.S. Treasuries.
   - FC is well-regarded but performance has been just average.

(3) Other large Italian companies:
   - Several have issued Euro-USD bonds with 5-year maturity
     Currently trading within a range of 40-70 bps.

• Evaluation
• The FC issue is trading at a relative high spread.
   – The issue might suffer from poor design.
   – Deterioration of perception
   – Call provision.

• Merotex's track record is limited but very good.
   – Merotex's GBP bonds have been well received in the market.
   – Merotex plans to include one UK house in management group.
Proposed Issue

Amount:
- The issue size should be sufficient to promote liquidity.
- But not so much as to make the placement process difficult.
- Proposed size: **USD 200 million** with a possible increase.

Maturity:
- For first timers shorter maturities are better: **5 years**.

Yield spread:
- Aggressive spread = 40 bps over 5-yr U.S. Treasuries.
- First-time issue: include a small premium: **Spread = 45 bps**.

The lead manager is able to formulate a pricing scheme:

<table>
<thead>
<tr>
<th>U.S. Treasury:</th>
<th>6.915% s.a. (semiannual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merotex spread:</td>
<td>0.45% s.a.</td>
</tr>
<tr>
<td>Merotex yield:</td>
<td>7.365% s.a., or 7.501% p.a. (annual)</td>
</tr>
</tbody>
</table>

⇒ Terms for investors: a 5-year Eurobond at a price to yield 7.50% p.a.

- **Fees (1¼% = USD 3.5M):**
  - Selling concession: ½% (Sellers buys the issue at 99¼).
  - Underwriting allowance: ½% (Underwriters pays 98½)
  - Managing fee: ¼% (Lead manager pays 98¼)

- **Final terms:**
  - Competitive bidding: Issuing house sells the issue at **99.24**
  - Coupon required to yield 7½% is lower.
  - Assuming YTM=r=7½, T=5, P=99.24, and FV=100, solve for C
  - \( C = 7.3113\% \).
  - Rounding up, the coupon rate is set at **7 (5/16)**.
  - Total coupon payment = \((7+5/16)*200\ M = USD 14.625\ M

The issue is priced at the selling concession.
Expenses
1.- Paying Agency: 100,000 bonds in USD 1,000 denominations
10,000 bonds in USD 10,000 denominations.
Total number of bonds: 110,000.
Coupon charge p.a.: USD .07 per coupon payment (USD 7,700)
Redemption charge: USD .70 per bond or USD 77,000
Authentication: USD 4,000 on delivery of bonds.
Administration: USD 2,000 (p.a.).

2.- Listing: USD 20,000 payable in advance.
3.- Trustee: USD 8,000 (p.a.) payable in advance.
4.- Other expenses: USD 80,000.

Pro Forma of the Issue
Borrower: Merotex C.A.
Guarantor: None
Amount: **USD 200 million**
Maturity: 5 years
Coupon: 7 (5/16) (= 7.3125%)
Issue price: 100%
Amortization: Bullet repayment on final maturity date
Issuer's call option: None
Listing: London
Denominations: USD 1,000 and USD 10,000
Form: Bearer securities

Commissions: 1¼% flat
Yield: 7.3125% (at issue price), 7.50% (at 99.24%)
Cash Flows of Merotex C.A. (in USD million):

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-200</td>
</tr>
<tr>
<td>Commissions</td>
<td>-3.500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paying Agency</td>
<td></td>
<td>-0.0077</td>
<td>-0.0077</td>
<td>-0.0077</td>
<td>-0.0077</td>
<td>-0.0847</td>
</tr>
<tr>
<td>Auth. &amp; Adm.</td>
<td>-0.004</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.002</td>
</tr>
<tr>
<td>Listing</td>
<td>-0.020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trustee</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.008</td>
</tr>
<tr>
<td>Reimburs. exp.</td>
<td>-0.080</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

⇒ Cost of funds (IRR) = 7.7778% p.a.

Note: Sometimes, IRR is calculated by excluding annual & minor expenses (listing, trustee, authentication, etc.). Under this method, IRR = 7.7580%.

Cost of Funds Exclusive Annual and Minor Expenses: Details

- This figure takes account:
  - Coupon payments (USD 14.625 M)
  - Commissions of 1¾% flat on the issue amount (USD 3.5 M)
  - Reimbursable managers' expenses (USD 80,000)

The issuer receives the net proceeds of:
USD 200,000,000 - USD 3,580,000 = USD 196,420,000 (or 98.21%)

- All-in cost: IRR of a 5-year project:
  - Positive cash flow of USD 196.42 M in year zero.
  - Negative cash flows of USD 14.625 M every year.
  - Negative cash flow of USD 200 M in year 5.

IRR = 7.7580%. (Merotex obtains financing at a cost of 7.7580% p.a.)
⇒ Small difference between both IRRs.
Cost of Funds Inclusive Annual and Minor Expenses: Details

This figure takes account:
- Coupon payments
- Commissions of $1\frac{3}{4}$% flat on the issue amount
- Reimbursable managers' expenses
- Commissions and Expenses

\[ \Rightarrow \text{IRR} = 7.7778 \text{ % p.a.} \] (Merotex obtains financing at a cost of 7.778% p.a.)

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Equity Warrants in Eurobonds

- *Equity warrant issues* have different components:
  - A standard fixed-rate Eurobond issue
  - A detachable equity warrant.

Equity warrant: A call option on the stock of the issuer.
\[ \Rightarrow \text{Tend to have longer maturities than standard options.} \]

The equity warrant is typically detached.

*Exercise ratio:* Number of shares a warrant buys.
• The bond is priced as normal.
• The warrant is priced as a function of: warrant premium & equity content.

• There is a unique price:
  (1) 100 percent: the bond price will be at a discount to par and the coupon at a below-market level (discount bond);
  (2) in excess of 100 percent: the bond is issued at a normal market price, that is, close to 100 percent (full coupon bond).

• Black-Scholes formula is used to approximate the value of the warrant.
  Traders make adjustments to the BS formula based on:
  (1) prices of other warrants
  (2) market perception on the company
  (3) expectations of the performance of the stock market.

• The ratio of equity raised to the issue size is the equity ratio.
  Usual range: 100% to 200% of the nominal amount of the bond issue.

• Q: Why do firms use equity warrants?
  A: For raising equity capital at a lower IRR.
Case Study II: VOMF

- Information
  - German company in the uranium business, with good reputation.
  - VOMF wants to refinance debt for USD 100 million. Seeking maturity in the range 5-7 years maturity (the longer the better).

- Market conditions:
  - Uranium prices are up.
  - German economy is coming out of a recession.
  - Inflation is very low.
  - The stock market is expected to do well in the near future.

VOMF's situation:
  - VOMF's share price is up because of exploration agreements.
  - Shareholders might increase capital in the next assembly.
  - VOMF has outstanding debt in the Euro-USD segment. It is currently paying a spread of 90 bps over US Treasuries.

An investment bank suggests an equity-linked financing
  ⇒ A straight bond with equity warrants attached.
**Data available**

<table>
<thead>
<tr>
<th>US Treasury yields:</th>
<th>3-year 6.530% (s.a.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5-year 6.915% (s.a.)</td>
</tr>
<tr>
<td></td>
<td>7-year 7.135% (s.a.)</td>
</tr>
<tr>
<td>EUR Bund interest rate:</td>
<td>1-year 4.52% (p.a.)</td>
</tr>
<tr>
<td>VOMF Euro-USD bond yield:</td>
<td>U.S. Treasuries + 90 bps</td>
</tr>
<tr>
<td>VOMF's share price ($P_0$):</td>
<td>EUR 120</td>
</tr>
<tr>
<td>Historic dividend yield:</td>
<td>5.50%</td>
</tr>
<tr>
<td>Historic stock price volatility:</td>
<td>3-year 19.90%</td>
</tr>
<tr>
<td></td>
<td>5-year 21.40%</td>
</tr>
<tr>
<td></td>
<td>7-year 25.50%</td>
</tr>
</tbody>
</table>

### Outstanding warrants

| Outstanding life: | 3½ years |
| Current price ($W_0$): | USD 10-10.80 (EUR 15.625-17) |
| Exercise price ($X$): | EUR 145 |
| Current exchange rate: | .64 USD/EUR (1.5625 EUR/USD) |

**Evaluation**

- **Warrant maturity:** 3 years (close to the life of outstanding issue).
- **Equity content:** 150% (good market conditions). Exercise ratio: 1
- **Pricing warrant:**
  
  Black-Scholes formula (theoretical price): EUR 12.23.

  VOMF's outstanding warrants trade EUR 16, with a GP:

  \[
  GP = \frac{(X + W_0)}{P_0} = \frac{(145 + 16)}{120} = 1.3417. \quad \text{(or 34.17%)}
  \]

  Investment bank proposes 3-year equity warrants with a GP \approx 35% & \quad \quad X = \text{EUR 150} \quad \text{(to minimize competition)}

  Warrant price = GP \times P_0 - X = 1.35 \times \text{EUR 120} - \text{EUR 150} = \text{EUR 12}

  \Rightarrow \quad \text{At this price, the implied volatility is equal to 19.63%}.

- **Pricing bond:**

  Maturity = Market conditions indicate a 7-year bond.

  \[
  \text{YTM} = 7\text{-year US Treasuries} + 90 \text{ bps} = 7.225\% \text{ s.a. (7.3555\% pa)}
  \]
Proposed Issue

* Terms for the warrants

(Imagine a conversion rate of 0.64 USD/EUR)

Amount of equity raised:

\[ \text{USD} 100,000,000 \times 1.50 = \text{USD} 150,000,000 = \text{EUR} 234,375,000 \]

Number of shares created on exercise:

\[ \frac{\text{EUR} 234,375,000}{\text{EUR} 150} = 1,562,500 \]

Exercise ratio: 1

Number of warrants: \( \frac{1,562,500}{1} \)

Number of bonds: 100,000

Number of warrants per bond: \( \frac{1,562,500}{100,000} = 15.625 \)

Value of the warrants attached to each bond of USD 1,000:

\[ 15.625 \times \text{EUR} 12 = \text{EUR} 187.50 = \text{USD} 120 \] (12% of nominal amount)

* Terms for the bond

Amount = USD 100 million (in denomination of USD 1,000)

Maturity = 7 years.

Yield = 7.3555% p.a.

Total commissions are 2%.

The bonds are offered at 98.78 percent (competitive pressures)

VOMF’s coupon is reduced to 7 ⅛% p.a.

Full-coupon bond which trades better in the secondary market.

Issue price (bond & warrants): 112%

Cost of funds (based on total issue price less commissions of 2%): 5.372% p.a. or 5.302% s.a.

\[ \Rightarrow \text{IRR: 183 bps (s.a.) below the yield on 7-year U.S. Treasuries.} \]
Case Study III: Bioneth

**Selecting a Particular Bond**

Simple process:

1. Compute the cost of funds of different instruments under different scenarios.
2. Based on its risk tolerance, a firm decides on the best instrument.

We will present an example showing how a Portuguese firm, Bioneth Engineering, selects a Eurobond issue with currency options attached.

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**Eurobonds with Currency Options Attached**

Attached to a Eurobond issue, a currency option is securitized as a tailor-made listed warrant.

**Advantages over standard currency options**

*For Buyers:*
- Loophole: In some countries, rules prevent retail and institutional investors from buying currency options per se.
- Smaller denominations or contract sizes
- Longer exercise periods.

*For Issuers:*
- Adding a securitized option reduces the cost of the borrowing.

**Disadvantage for the issuer:** It creates an FX exposure for itself. The issuer may choose to hedge this exposure.
**Example:** Bioneth Engineering is a firm based in Portugal.

**Situation:**
- Bioneth has **GBP 100 million** of short-term debt.
- Refinance the GBP debt with a straight **7-year 8%** Euro-GBP bond.
- Market competitive pressures reduce commissions paid to **1¼%** (or **GBP 1.75M**).

An investment bank approaches Bioneth and offers:
A similar straight **7-year 8%** Euro-GBP bond, but with a **3-year currency warrants** attached giving entitlement to an American GBP-put/EUR call option with $X_p = 1.50$ EUR/GBP (or $X_c = .6667$ GBP/EUR) and a size of **EUR 1,600**.

**Note:** The warrant is a standard put. It will be exercised only when: $(X_p - S_t) > 0$.

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### Terms of the bond.

<table>
<thead>
<tr>
<th>Term</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amount:</strong></td>
<td><strong>GBP 100 million.</strong></td>
</tr>
<tr>
<td><strong>Maturity:</strong></td>
<td><strong>7 years.</strong></td>
</tr>
<tr>
<td><strong>Issue price:</strong></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Denominations:</strong></td>
<td>GBP 1,000 ($\Rightarrow 100,000$ bonds)</td>
</tr>
<tr>
<td><strong>Interest:</strong></td>
<td><strong>8%</strong> p.a. payable annually in arrears.</td>
</tr>
<tr>
<td><strong>Early redemption:</strong></td>
<td>None.</td>
</tr>
<tr>
<td><strong>Redemption price:</strong></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Issuance commissions:</strong></td>
<td><strong>1¼%</strong> (GBP 1.75M).</td>
</tr>
<tr>
<td><strong>Listing:</strong></td>
<td>London</td>
</tr>
</tbody>
</table>

**Cost of funds (including only commissions): 8.34%**
• **Terms of the currency warrants**

Exercise price: **1.50 EUR/GBP** (.6667 GBP/EUR)

Exercise period: At any time.

Current exchange rate: **1.60 EUR/GBP** (.6250 GBP/EUR)

Structure: Each bond has a warrant giving the right to receive the difference between:

1. the GBP equivalent of EUR 1,600 at $X_p = 1.50 EUR/GBP$, and
2. the GBP equivalent of EUR 1,600 at $S_t$.

Warrant price: **EUR 0.04935** per GBP. At $S_t$, **GBP 0.0308** or GBP 30.80 per bond (**3.08%**).

Premium of X/S: 0.6667/0.6250 = 1.0667 or 6.67%

Issue price (bond & warrants): 100% + 3.08% = 103.08%

Note: The warrant is a standard put. It will be exercised only when: $(X_p - S_t) > 0$.

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• **Evaluation**

- At expiration, two scenarios for GBP put:
  - if $S_{t+3\ yrs} > X_p = 1.50 EUR/GBP$ ⇒ no exercise.
  - if $S_{t+3\ yrs} < X_p = 1.50 EUR/GBP$ ⇒ exercise.

**Example:** If $S_{t+3\ yrs} = 1.40 EUR/GBP$ (.7143 GBP/EUR), exercise.
⇒ receive, per bond:

**EUR 1,600 * .7143 GBP/EUR − EUR 1,600 * .6667 GBP/EUR = GBP 76.19.**

- Bioneth is exposed to currency risk.

If $S_{t+3\ yrs} = 1.40 EUR/GBP$, Bioneth has an additional cash flow of **GBP 76.19 * 100,000 = GBP 7,619,000.**

⇒ Total CFs at t+3 = GBP -8M + **GBP -7.619M = GBP -15.619M**
• **Evaluation**

  • To hedge, the investment bank offers Bioneth an identical currency option at **EUR 0.04** per GBP or **GBP 25** per GBP 1,000 bond.

  That is, Bioneth can buy FX insurance for an upfront cost of
  
  **GBP 25/bond * 100,000 bonds = GBP 2.5M.**

  ⇒ At inception, Bioneth receives
  
  GBP 100M – **GBP 1.75M** + GBP 3.08M – **GBP 2.5M** = GBP 98.83M.

• Suppose the investment bank considers likely \( S_{t+3\text{yrs}} = 1.40 \text{ EUR/GBP} \).

  Bioneth compares the cash flows under different alternative scenarios:

<table>
<thead>
<tr>
<th>Date</th>
<th>Str. Bond CO Bond (NH/NExercised)</th>
<th>CO Bond (NH/Exercised)</th>
<th>CO Bond (Hedged)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>98.250</td>
<td>101.330</td>
<td>101.330</td>
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<tr>
<td>1</td>
<td>-8.000</td>
<td>-8.000</td>
<td>-8.000</td>
</tr>
<tr>
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</tr>
<tr>
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<td>-8.000</td>
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<tr>
<td>6</td>
<td>-8.000</td>
<td>-8.000</td>
<td>-8.000</td>
</tr>
<tr>
<td>7</td>
<td>-108.000</td>
<td>-108.000</td>
<td>-108.000</td>
</tr>
</tbody>
</table>

  **IRR:** 8.340% 7.747% 8.904% 8.227%

  ⇒ Bioneth issues bond with currency options attached and also hedge.
Case Study IV: Brady Bonds

- **Brady Bonds (BBs)**
  - Created to bring EM (Mexico, Brazil, etc.) out of the 1980s default.
  - USD 180 billion market in its heyday.
  - Secretary Brady’s idea: Banks voluntarily reduce their claims in return for credit enhancements on their remaining exposure: collateral accounts to guarantee the principal and/or interest in a bond exchange or cash payments in the context of buybacks.
  - Mexico, Costa Rica, and Venezuela were the first three countries to issue bonds as part of the Brady plan.
  - Issued two *Brady bonds* for debt conversion:
    - A *par bond* (fixed-rate)
    - A *discount bond* (floating-rate)

- **Brady Bonds: Mexican BBs**
  - Mexican Brady bonds were issued in March 1990, with T = 30 years.
    - Principal of bonds: Guaranteed by 30-year U.S. Treasury zero-coupon bonds.
    - A rolling interest guarantee (RG) is provided by a pool of collateral sufficient to cover 18-mo of coupon payments –3 semester payments– at an assumed coupon rate of 10%.
    - Banks have a choice of BBs to exchange for defaulted debt:
      - Par Bond: C = 6.25%. Bank debt exchanged for the par bond with principal equal to the original face value of the debt.
      - Discount Bond: C = LIBOR + 13/16. But, bank debt exchanged at the discount 65% ratio.
    - Both bonds include an oil price recapture clause that pays off if oil prices rise in 1997 and beyond.
**Brady Bonds: Cash Flows**
The coupon CFs follow a simple binomial tree, where $P_t$ is the probability of default at time $t$, with $t = 1, 2, \ldots, 60$.

\[ \begin{align*}
\text{RG} & \quad P_1 \quad 1-P_1 \\
\text{RG} & \quad P_2 \quad 1-P_2 \quad \frac{C}{2} \\
\frac{C}{2} & \quad \text{RG} \quad P_3 \quad 1-P_3 \quad \frac{C}{2} \quad \frac{C}{2} \\
\frac{C}{2} & \quad \frac{C}{2} \quad \text{RG} \quad P_4 \quad 1-P_4 \quad \frac{C}{2} \quad \frac{C}{2} \quad \frac{C}{2} \\
\frac{C}{2} & \quad \frac{C}{2} \quad \frac{C}{2} \quad \text{RG} \quad P_5 \quad 1-P_5 \quad \frac{C}{2} \quad \frac{C}{2} \quad \frac{C}{2} \quad \frac{C}{2} \quad \frac{C}{2}
\end{align*} \]

- To get an NPV, we need to discount CFs with appropriate YTM (local YTM for C and US YTM for RG). We also need a model for default!

**Brady Bonds: Cash Flows and Discount Rates**
- The principal is guaranteed with US T-bonds. That is, after 30-years it will be repaid. Easy to calculate the NPV of Principal, using 30-year US YTM as discount rate.

- Coupon payments involve risk. Default can happen at any time. There is uncertainty regarding the amount of coupon payments received by the bondholders.

  - As a minimum, a bondholders receives RG: RG kicks in immediately after default. It involves 3 C/2 payments. Use appropriate US YTM to discount CFs.

  - The risky CFs are the ones not covered by guarantees: All coupon payments, beyond the RG. Use appropriate Mexican YTM to discount these CFs.
Brady Bonds: Cash Flows and Default Probabilities

- We need to calculate the probability associated with each final coupon CF at the each branch of the binomial tree.

Suppose there is default at \( t = 3 \) –i.e., after 2 coupon payments. Then, the are 5 payments. That is, the CFs for the bondholder are: \{C/2, C/2, RG\}.

The probability of receiving 5 coupon payments only –i.e., default occurs after \( t = 3 \)– is given by:

\[
(1 - P_1) * (1 - P_2) * P_3
\]

- By multiplying each final coupon CFs at each branch by its probability and adding them up, we calculate the expected NPV of coupon CFs, or \( E[NPV_{Coupons}] \).

Then, add the NPV of Principal (paid with certainty). That gives us \( P_{BB} \).

Brady Bonds: Default Probabilities

- To calculate an expected \( E[NPV] \), we need a model for the probability of default. Many ways to approach this problem. For example, we can use an inverted U shape for the probability of default:

- Alternatively, we can buy a *credit default swap* or CDS –i.e., insurance – to cover the event of default of coupon payments (more on this next chapter). Although, there was no CDS market at the time of the issuance of Brady bonds.