Bond Trading & Portfolio Management

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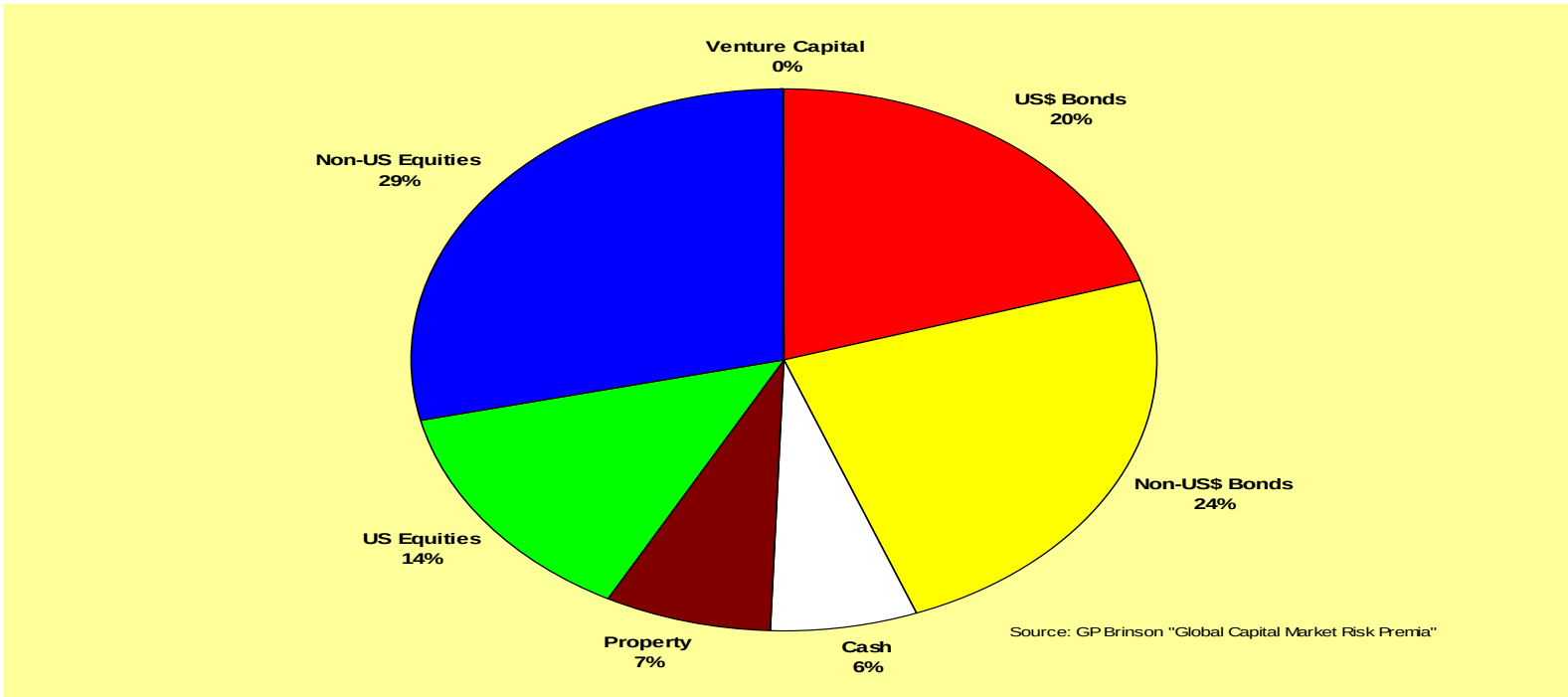
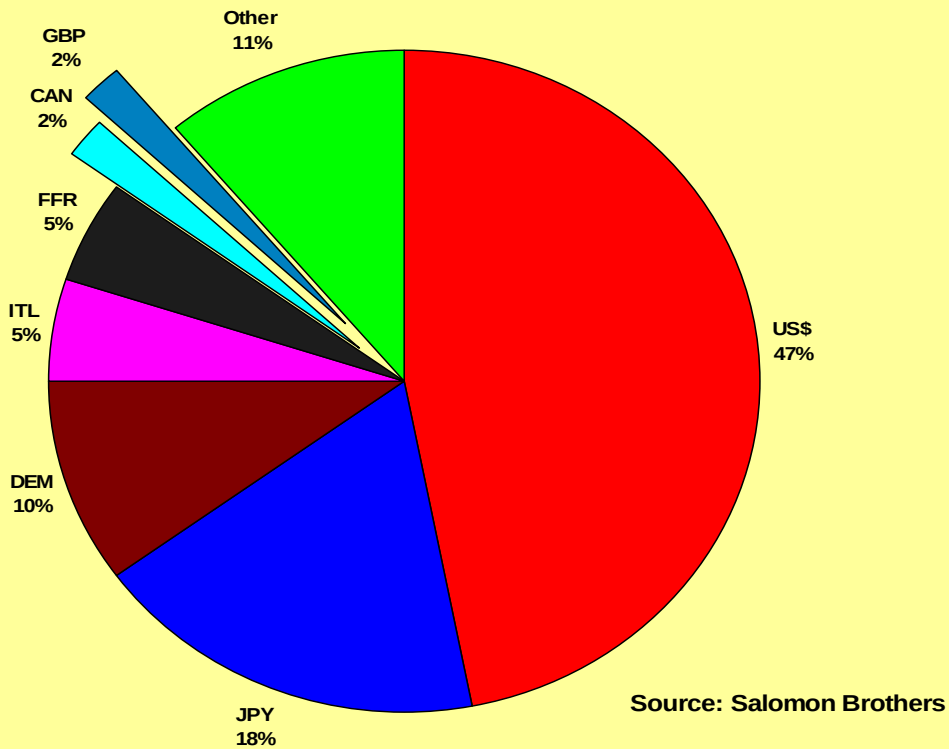
Bond Portfolio Management

- Role of debt in capital markets
- Risk-Return Characteristics of Bonds
- Key Bond Portfolio Management Tools
- Passive Bond Management
- The Impact of Taxes
- Bond Efficiency
- Tax Arbitrage
- Bond Portfolio Dedication & Improvement
- Building an After-Tax Yield Curve

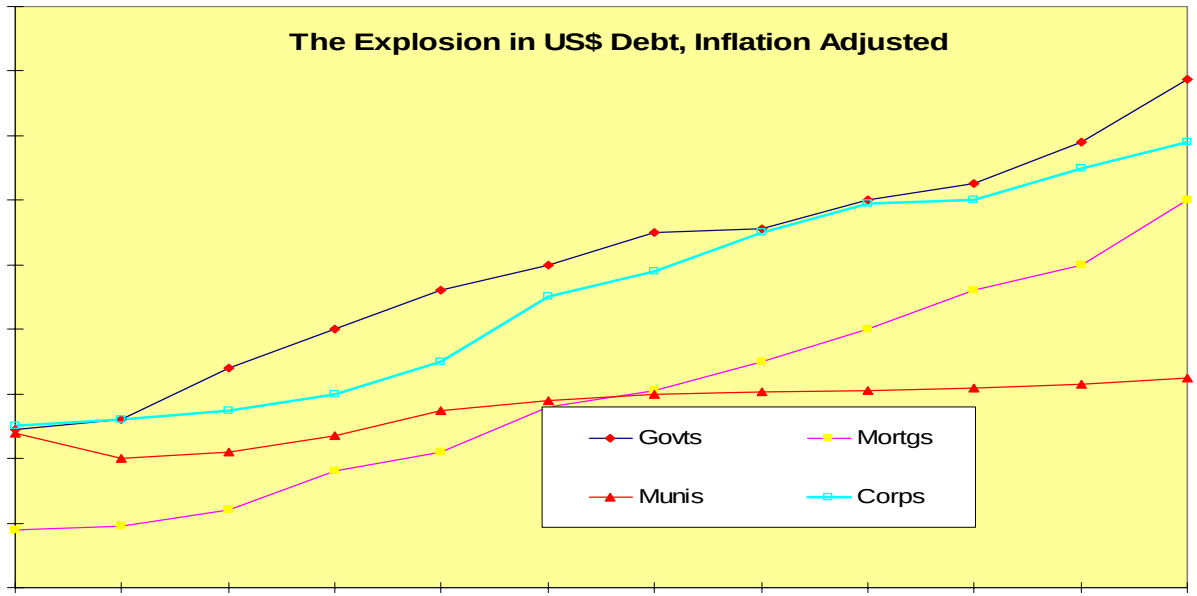
World Capital Markets



Bond Markets by Currency



US Debt Explosion



Portfolio Management Overview

- Why do investors hold equities?
- Equities are risky
- BUT . . .
- Equities provide a risk premium

Portfolio Theory & CAPM

- Portfolio Theory
  - Equities are imperfectly correlated
    - non-systematic risk
- Diversification improves the risk-return trade-off
- CAPM: investors should hold market portfolio

Why Hold Bonds?

- Do bonds provide a risk premium?

- Do bonds have significant non-systematic risk?

Evidence on Risk Premia in US Equity & Bond Markets: 1926-92

	Average Rate of Return		Average
PORTFOLIO	**Nominal**	**Real**	**Risk Premium**
Stocks	12.4	9.2	8.6
Corp. Bonds	5.8	2.6	2.0
Govt. Bonds	5.2	2.0	1.4
T-Bills	3.8	0.6	-

Source: Ibbotson & Sinquefield

Are Bonds Much Less Risky than Stocks?

	Return Variability	
MARKET	**Stocks**	**Bonds**
France	22.5	7.9
Germany	22.2	6.6
Switzerland	20.0	5.6
UK	19.6	9.5
US	16.6	10.5

(Jan 1985 - Dec 1992)

Source: Ibbotson & Sinquefield

Do (riskless) bonds have significant non-systematic risk?

- What is “security specific” about a government bond?

- Two or three factors explain most (>95%) of variation in returns

Risk Characteristics in Equities and Bonds

	Equities	Bonds
Market Risk	30%	95-99%
Specific Risk	70%	1-5%
Total	100%	100%

Implications for Portfolio Management

- STOCKS:
  - Security Analysis
  - Diversification
- BONDS
  - Risk Management
  - Tax

Security Analysis

- EQUITIES
  - Need to forecast future dividends
  - Evidence suggests limited forecasting ability on part of analysts
- BONDS
  - Know everything about the cash flows
  - Can reliably detect mis-priced bonds

Implications for Active/Passive Management

	Equities	Bonds
Diversification	Very Important	(much) Less Important
Connection with Liability Structure	Limited Importance	Cash Matching Duation Matching
Tax	Limited Importance	Very Important

Bond Portfolio Management: Key Tools

- Relative Value
  - Zero Coupon Yield Curve
    - Measuring the term structure
    - Tax structure
  - Option Related Valuation
- Risk/Return Trade-Off
  - Term Structure Theory
    - analogue to CAPM
    - evidence on premium mixed
  - Default Risk
    - risk/reward trade-off for low-grade bonds
- Risk Management
  - Relation to liabilities
  - Duration/Immunization
  - Convexity
  - Currency Hedging

Passive Bond Management

- Assume bond prices fairly set
- Seek to control portfolio risk
- Two major strategies
  - Indexation
  - Immunization

Bond Indexes

- Salomon Bros.
  - Broad Investment Grade (BIG) Index
- Merrill Lynch
  - Domestic Master Index
- Lehman Brothers
  - Aggregate Index

Bond Index Features

- Number of issues: over 5,000
- Maturity of bonds: over 1 year
  - Bonds are dropped as approach maturity
- Bond types:
  - Included: government, corporate, Yankee
  - Excluded: Junk bonds, convertibles
- Weighting: market value
- Computed: daily

Problems with Creating Bond Index Funds

- Large number of bonds
  - Difficult to purchase every security in proportion to market value
- Illiquidity
  - Purchase at fair market price can be difficult
- Rebalancing
  - New bonds continually added
  - Bonds continually dropped as they mature

Index Stratification

	SECTOR						
Term	**Treasury**	**Agency**	**Mortgage-Backed**	**Industrial**	**Finance**	**Utility**	**Yankee**
<1 yr	12.1%						
1-3 years	5.4%						
3-5 years			4.1%				
5-7 years							
7-10 years		0.1%					
10-15 years							
15-30 years			9.2%			3.4%	
30+ years							

Bond Index Funds

- Cellular approach
  - Replicate overall characteristics of index
- Tracking error
  - Difference between portfolio and index return
    - Salomon study - error only 4bps pm on BIG index
- Investors
  - $100bn pension fund assets in bond-index portfolios in 1995
  - Retail investors: mutual index funds
    - Vanguard fund pegged to BIG index

Rebalancing

- Durations of assets & liabilities will change:
  - As interest rates change
  - As time passes
  - At different rates
- Hence asset & liability durations need continual re-alignment
  - Called portfolio *rebalancing*
- Immunization is a *passive* strategy
  - Does not try to identify undervalued securities
  - BUT: positions are actively monitored & updated

Bond Portfolio Dedication & Improvement

- Funding cash flows for retirees of a pension fund
- Maintaining cash flow of existing portfolio but reducing cost (portfolio improvement)
- Cost of funding an annuity (or other financial product)

Tax Effects

- Tax effects in most bond markets
- Tax effects are important even for tax-exempt investors
- Tax effects typically create arbitrage opportunities, depending on:
  - frictions (spreads)
  - short-selling constraints
  - asymmetric tax treatment of long and short positions

Summary of Analysis Without Taxes

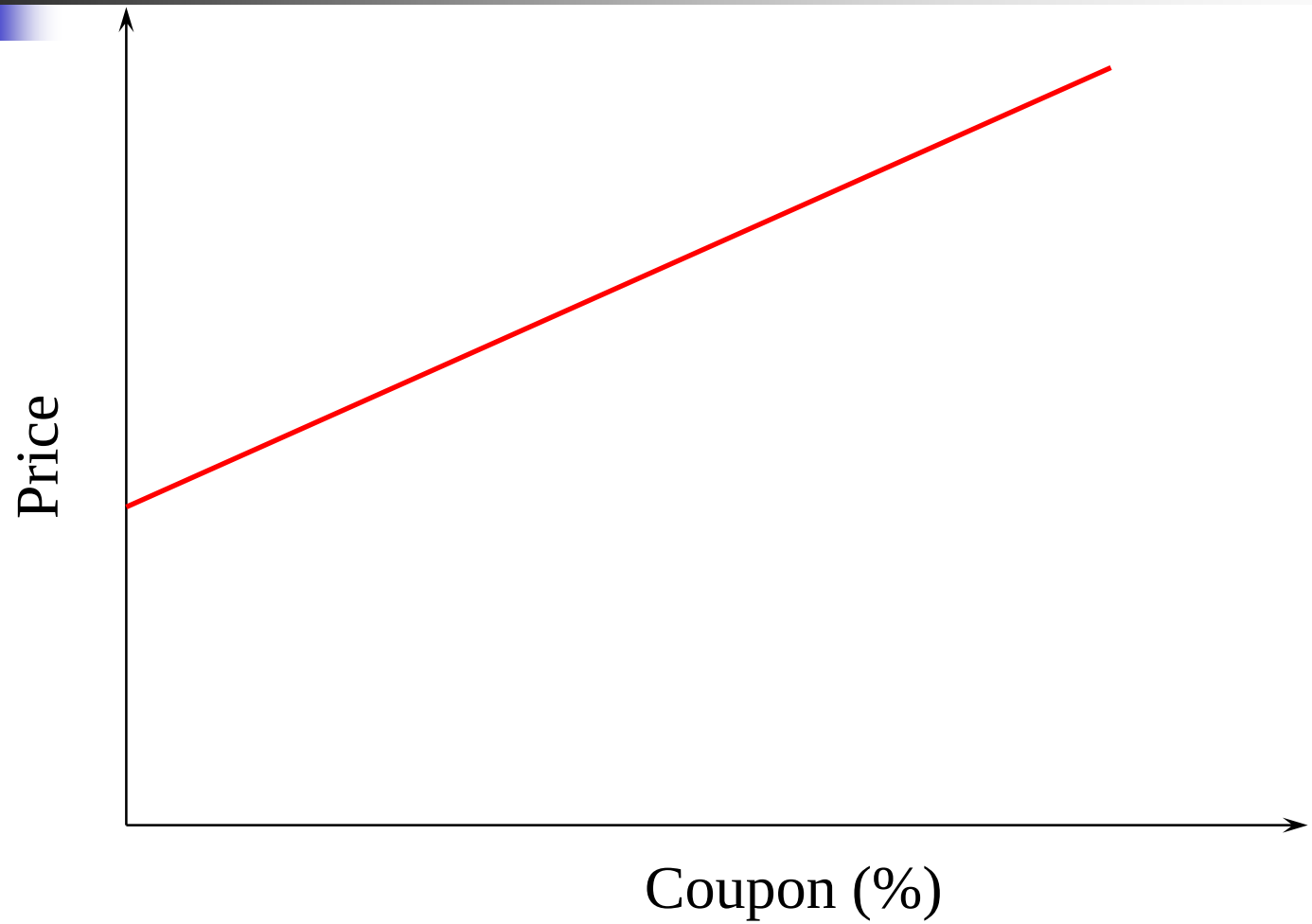
- Price = Present value for each bond (all, bonds, all investors)
- Each investor prepared to hold any bond
- PRICE = COUPON X ANNUITY FACTOR
  + 100 X DISCOUNT FACTOR

$$P = \sum_{1}^{n} C \times D_i + 100 \times D_n$$

$$P = C \times \sum_{1}^{n} D_i + 100 \times D_n$$

$$P = C \times AF + 100 \times D_n$$

The Price-Coupon Relationship with No Taxes



The Problem of Tax Effects

- Investors in different tax brackets will not agree on relative value of bonds

	After Tax Cash Flows		
Coupon	**T = 0%**	**T = 30%**	**T = 60%**
3%	103	102.1	101.2
9%	109	106.3	103.6
15%	115	110.5	106
V15/V3	115.0/103.0	110.5/102.1	106.0/101.2
	= 1.117	= 1.082	= 1.047

Tax Analysis of Bonds

- Suppose we live a world with 3 coupon bonds
  - All three are 1 year bonds
  - Coupons are 3%, 9% and 15%
  - The 1 yr. spot rate is 10%
- Suppose we have 3 groups of tax-payers
  - 0%, 30% and 60%
- What are the bond prices?
  - What are the post-tax cash flows?
  - What are the post-tax yields?
- Use worksheet: Bonds & Taxes

Solution: Tax Analysis of Bonds

	BOND		
	1	2	3
Coupon	3%	9%	15%
Price	93.64	99.09	104.55
After-tax cash flows			
Tax rate 0%	103.0	109.0	115.0
Tax rate 30%	102.1	106.3	110.5
Tax rate 60%	101.2	103.6	106.0
After-tax yield			
Tax rate 0%	10%	10%	10%
Tax rate 30%	9.0%	7.3%	5.7%
Tax rate 60%	8.1%	4.6%	1.4%

Implications of Tax Analysis

- A Zero Tax Payer
  - All the bonds offer the same yield
  - Hence, s/he will hold any of the bonds
- A Tax Payer
  - Will receive higher yield on low coupon bond
  - Hence, will prefer a low coupon bond to high coupon bond

Efficient Bonds

- Bond Price > NPV of cash flows for some investors
- An Efficient Bond:
  - Price = NPV
- Example:
  - The 3% coupon bond is efficient
  - For both 30% and 60% taxpayers
- Next Issue: What is the spot rate?

Post-Tax Spot Rate

- Post-Tax Yields: Non-Taxpayer
  - For the 0% tax payer, the yield on all bonds is 10%
  - Hence pre-tax spot rate = post-tax spot rate = 10%
- Post-Tax Yields: Taxpayers
  - Yields vary for each bond
  - Which yield is the post-tax spot rate?
- The Post-Tax Spot Rate: the *highest* yield
  - The yield on the *efficient* bond
- Example:
  - For 30% taxpayers, post-tax spot rate is 9%
  - For 60% taxpayers, post-tax sport rate is 8.1%

Tax Specific Yield Curves

- Investors in different tax brackets will see the same price for different after-tax cashflows
- No one investor will set prices for all bonds
- Different investors will therefore have different after-tax discount factors and yield curves
- Investors in different tax brackets may or may not agree to hold the same bond

Post-Tax Bond Valuation

- Spot rates are different for different tax brackets
- So they will not agree on bond values
- Example: and 8% coupon 1 year bond
  - Use the Bonds & taxes worksheet
  - Use the post-tax spot rates
  - Find the NPV of the post-tax cash flows

Example: Bond Valuation

- Value of an 8% 1-year Bond

Tax Rate	Post-Tax Spot rate	Post-Tax Cash Flow	Present Value
0%	10.0%	108.0	98.18
30%	9.0%	105.6	96.88
60%	8.1%	103.2	95.47

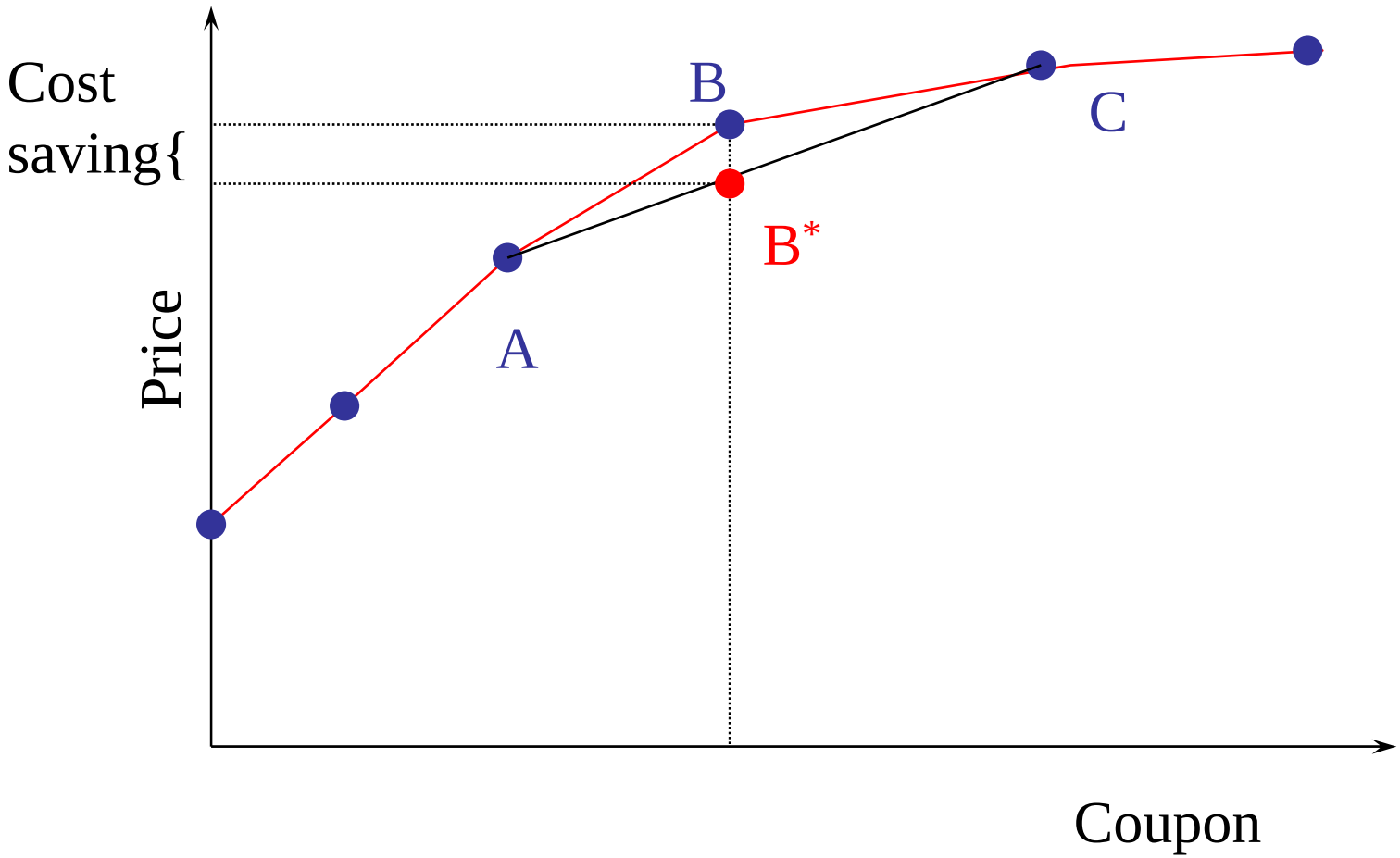
Tax Clientele Hypothesis

- No Tax Effects
  - All bonds priced so they can be held optimally by a 0% tax payer
  - Price coupon relationship linear
  - No arbitrage
- Clientele Effects
  - Different bonds prices so they can be held optimally by different tax-clienteles of investors
  - Price coupon relationship non-linear
  - Arbitrage

Tax Implication

- Assume different tax rates
- Bonds with different coupons
- Then there will be a tax arbitrage for at least one tax bracket
  - Note: Green & Oedegaard reject the no-tax hypothesis in formal test of US market

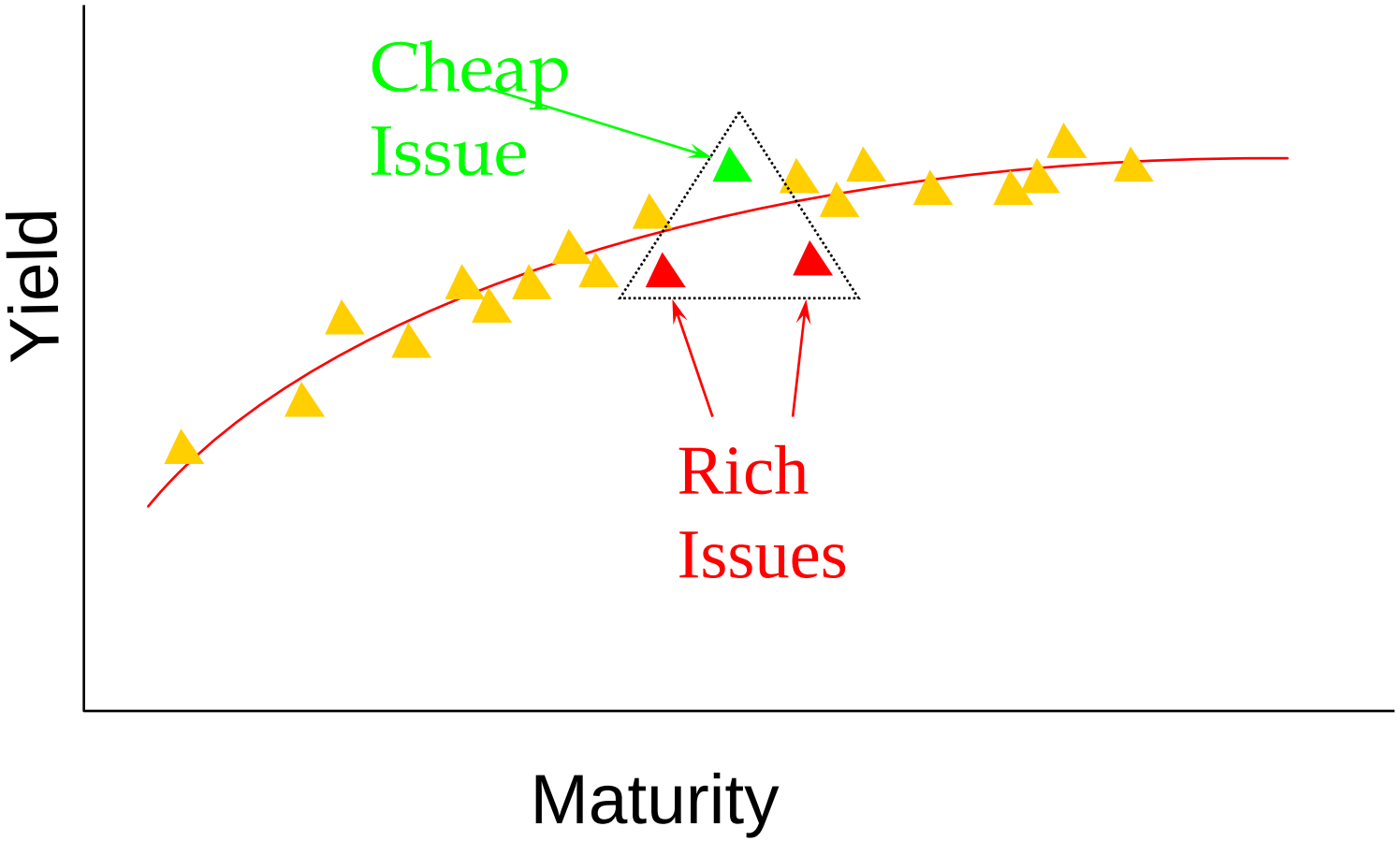
Tax Arbitrage: Non-linear Price-Coupon Curve



Rich/Cheap Analysis & Relative Value Trading

- Select the appropriate tax-rate
- Identify the tax-efficient bonds
- Plot the spot tax-yield curve using the efficient bonds
- Identify the issues which are low yield (‘rich’) or high yield (‘cheap’) relative to the curve
- Initiate duration-weighted trade

Rich/Cheap Graphical Analysis



Example: Bond Replication

Bond	Coupon	Cash Flows	Price
A	3%	103	93.64
B	5%	105	96.00
C	8%	108	98.18

- Replicate Bond B, using Bonds A & C:
  - Create $B^* = W_1 A + W_2 C$
  - Require W_1 and W_2 so that
  - $W_1 (103) + W_2 (108) = 105$
  - $W_1 + W_2 = 1$

Example: Bond Replication

- Create replicating Bond B*
  - B* = 3/5 A + 2/5 C
- Check cash flows:
  - 3/5(103) + 2/5(108) = 105
- Cost Saving
  - Price of Bond B 96.00
    Cost of B* = 3/5(93.64) + 2/5 (98.18) 95.45
    Cost Saving 0.55
- Arbitrage Trade
  - Sell 10 x Bond B_____
  - Buy 6 x Bond A and 4 x Bond C
  - Riskless profit of $5.50

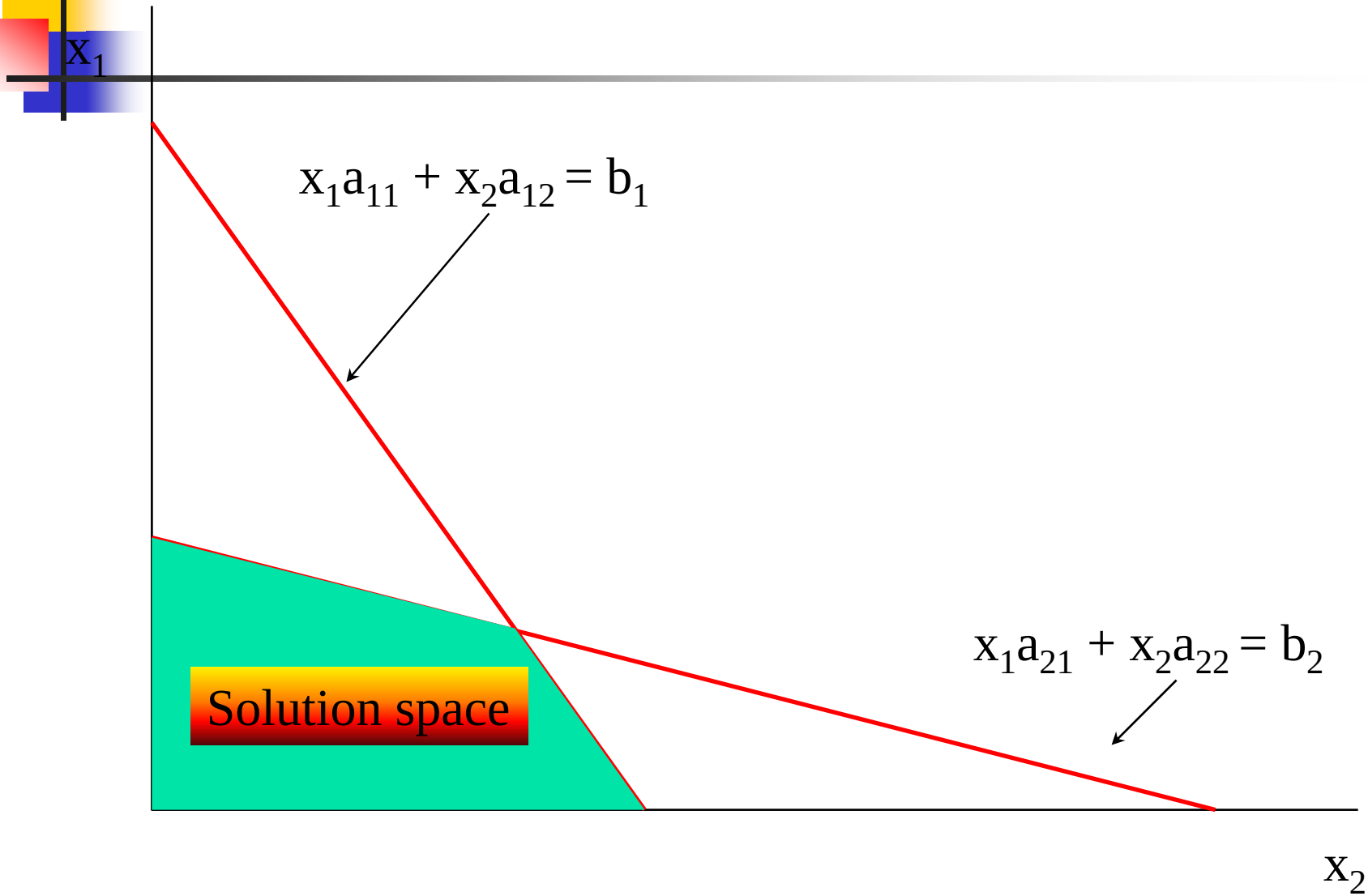
Tax Arbitrage: Basic Idea

- Use LP to find bond portfolio which replicates CF's of target bond, more cheaply.
  - Will identify & use efficient bonds
- Pick a target bond & replicate test for each tax rate.
- Restrictions on arbitrage:
  - Transaction costs
  - Short sale restrictions

Linear Programing

- Maximize (or minimize) an objective function subject to a set of constraints
- Objective function and constraints must be linear
  - Maximize $x_1p_1 + x_2p_2$
  - Subject to:
    - $x_1a_{11} + x_2a_{12} <= b_1$
    - $x_1a_{21} + x_2a_{22} <= b_2$

Linear Programing



Summary: Tax Effects

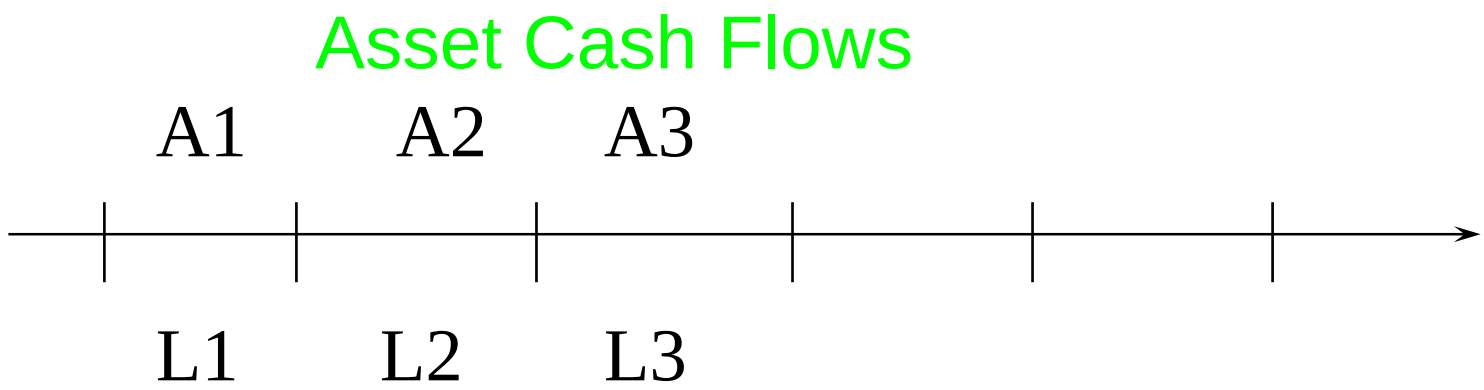
- Taxes important for *both tax paying and tax-exempt* investors
- Strong evidence of *tax-clienteles*
- Taxes will influence investors **choice** of bonds
- A non-linear price-coupon relationship implies *arbitrage opportunities*
  - Studies in Germany, Japan, UK & USA all show that prices reflect non-zero income and capital gains taxes

Application: Bond Portfolio Dedication & Improvement

- Funding cash flows for retirees of a pension fund
- Maintaining cash flow of existing portfolio but reducing cost (portfolio improvement)
- Cost of funding an annuity (or other financial product)

Dedicated Portfolio

- Asset cash flows match liability cash flows
  A1 = L1, A2 = L2, A3 = L3 . . . .



Example: Dedicated Portfolio

Bond	Price	Coupon	Maturity
1	97.88	5%	1
2	93.13	3%	2
3	100.00	8%	2
4	91.88	4%	3
5	104.01	10%	3

- Required Cash Flow Year

100	1
200	2
300	3

Structuring the Dedication Problem

- See Worksheet: Dedicated Portfolio Problem

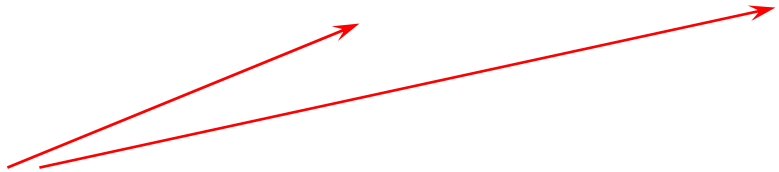
		Bonds					Target
		1	2	3	4	5	
Coupon		5%	3%	8%	4%	10%	
Price		97.88	93.13	100.00	91.88	104.01	
YEAR	1	105	3	8	4	10	100
	2	0	103	108	4	10	200
	3	0	0	0	104	110	300

Lab: Using Linear Programming

- Worksheet: Bond dedication
- We will use Excel Solver
- Follow my demonstration
- See cell notes for help

Dedication: Tax Rate = 0%

	Bonds					Min Cost	Lagrange Multiplier
	1	2	3	4	5		
Qty	0.571	0.000	1.599	0.000	2.727		
Price	97.88	93.13	100.00	91.88	104.01		
Cost	55.87	0.00	159.93	0.00	283.66	**499.46**	
1	105	3	8	4	10	100	0.9322
2	0	103	108	4	10	200	0.8569
3	0	0	0	104	110	300	0.7829
NPV	0.00	-2.08	0.00	-3.30	0.00		



- Note: These bonds are inefficient at 40% tax - we can replicate them more cheaply using other bonds

Notes on Solver Output

- Lagrange Multiplier
  - Found on Sensitivity Report
  - How much it would cost to generate another $1 of cash flow in year 1, 2 or 3 ?
  - This means the same thing as a discount factor:
  - $FV_i \times DF_i = \$1$
  - Example $DF_1 = 0.9322$, so we could generate another $1 in year 1 by spending $0.9322 today
- Yield
  - $DF_i = 1/(1+Y_i)^i$
  - Y_i is the after-tax spot rate in year i

Lab: Dedication Problem Tax rate = 40%

- Next: Set Tax Rate to 40%
  - Notice after-tax cash flows adjust
- Re-apply Solver to Dedication Problem
  - Reset quantities to zero
  - Delete Discount Factors
  - Restart Solver
  - Produce Sensitivity Report
  - Copy Lagrange Multipliers (DF's)

Lab Questions:

- In the portfolio cost lower or higher?
  - Why?
- Do the DF's change?
  - Why, or why not?
- Do the yields change
  - Why or why not?
- Compare the bond NPV's at 0% and 40%
  - Why are they different?
  - Which are the efficient bonds at 0%; at 40%?

Dedication Solution: Tax Rate = 40%

	Bonds					Min Cost	Lagrange Multiplier
	1	2	3	4	5		
Qty	0.869	1.896	0.000	2.930	0.000		
Price	97.88	93.13	100.00	91.88	104.01		
Cost	85.10	176.53	0.00	269.18	0.00	**530.82**	
1	103	1.8	4.8	2.4	6	100	0.9503
2	0	101.8	104.8	2.4	6	200	0.8980
3	0	0	0	102.4	106	300	0.8539
NPV	0.00	0.00	-1.33	0.00	-2.40		

- Note: These bonds are inefficient at 40% tax - we can replicate them more cheaply from other bonds
- Note: Portfolio cost is higher due to tax

NPV's at 0% and 40% Tax Rates

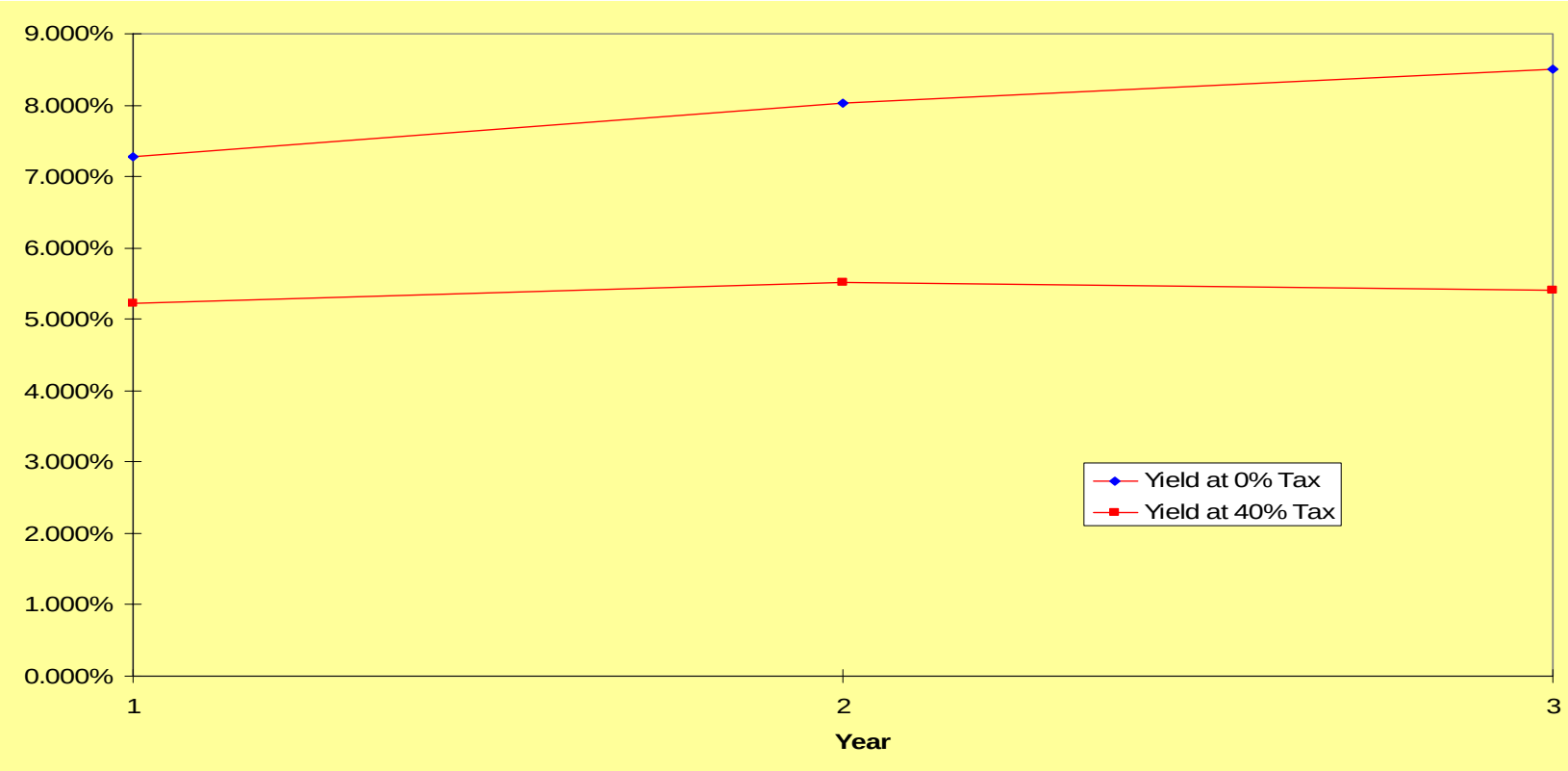
- Bond Efficiency:
  - Lower coupon bonds at higher tax rates
  - Higher coupon bonds at lower tax rates

		NPV	
Bond	**Coupon**	**Tax = 0%**	**Tax = 40%**
1	5%	0.00	0.00
2	3%	-2.08	0.00
3	8%	0.00	-1.33
4	4%	-3.30	0.00
5	10%	0.00	-2.40

Implied Zero Coupon Tax Yields

	0% Tax Rate		40% Tax Rate	
Year	Discount Factor	Zero Coupon Yield	Discount Factor	Zero Coupon Yield
1	0.9322	7.274%	0.9503	5.231%
2	0.8569	8.029%	0.8980	5.525%
3	0.7829	8.500%	0.8539	5.404%

Implied Taxed-Yield Curves



Portfolio Improvement

- Improvement:
  - You hold an existing portfolio
  - Can you achieve same cash flows at lower cost?
- Involves:
  - Computing Bond NPV's
  - Replicating inefficient bonds (-ve NPVs)
  - Use Solver
- Dedication vs. Improvement:
  - Dedication: Cash flows are fixed, minimize cost
  - Improvement: Reduce cost of existing cash flows

Lab: Portfolio Improvement

- Worksheet-Portfolio Improvement
- Use Solver
- Where did the cost savings come from?

Solution: Portfolio Improvement

	Bonds					Portfolio Cost
	1	2	3	4	5	
Initial	1.000	1.000	1.000	1.000	1.000	486.90
Final	0.908	0.000	1.903	0.000	1.945	**481.52**
Price	97.88	93.13	100.00	91.88	104.01	

					Initial	Final
1	105	3	8	4	10	130	130
2	0	103	108	4	10	225	225
3	0	0	0	104	110	214	214
NPV	0.00	-2.08	0.00	-3.30	0.00		

Achieved same cash flows at lower cost

Cost saving comes from selling bonds with NPV < 0

Coupon	Maturity	Initial	Final	Amount Sold	NPV	Saving = NPV x Amt
Portfolio Cost		486.90	481.52			**5.38**
5	1	1	0.908	0.092	0	0.00
3	2	1	0.000	1.000	-2.08	2.08
8	2	1	1.903	-0.903	0	0.00
4	3	1	0.000	1.000	-3.30	3.30
10	3	1	1.945	-0.945	0	0.00
Total						**5.38**

Extending the Basic Model

- Cash may be carried forward (invested) or backwards (borrowed) between grid dates at specified interest rates
- Limits on amount of any particular bond or category of bond (e.g. credit rating)
- Duration constraint may be included
- Swaps, forward contracts may be included

Building After-Tax Yield Curves

- Assumptions:
  - No short sales allowed
  - No transaction costs

After-Tax Yield Curves: Methodology

- Filter out inefficient bonds
- Use LP to find efficient bonds:
  - Bonds that minimize the cost of a given set of cash flows for an investor
- Build a yield curve from the efficient bonds
  - Use regression and basis splines
- The curve will be different for each tax bracket

LP Formulation for Bond Portfolio

- Optimal portfolio of bonds provides cashflows at a minimum cost so:
  - Minimize the cost of a given set of cashflows from a portfolio of bonds
- Notation:
  - j = 1, . . .,T Periods in time
  - I = 1, . . ., m Bonds in portfolio
  - x: Bond holding
  - p: Bond price
  - s: Cash flows from portfolio
  - d: Discount factor
  - a: After tax payment from bond

$$Min \sum_{i=1}^{m} x_i p_i$$

Subject to:

$$\sum_i a_{ij} x_i \geq s_j$$

$$x_i \geq 0$$

Equivalent LP Formulation

- Or: maximize discount cashflows from a given portfolio subject to a yield curve generated from efficient bonds
- Notation:
  - j = 1, . . .,T Periods in time
  - I = 1, . . ., m Bonds in portfolio
  - x: Bond holding
  - p: Bond price
  - s: Cash flows from portfolio
  - d: Discount factor
  - a: After tax payment from bond

$$Max \sum_{j=1}^{T} s_j d_j$$

Subject to:

$$\sum_{j=1}^{T} a_{ij} d_j \leq p_i$$

$$d_j \geq 0$$

LP & Basis Splines

- Use weighted sum of basis splines to represent discount function:

$$d(t_j) = \sum_{1}^{L} \alpha_l f_l(t_j)$$

$$Max \sum_{l=1}^{L} \omega_l \alpha_l \qquad \omega_l = \sum_{j=1}^{T} s_j f_l(t_j)$$

Subject to:

$$\sum_{l=1}^{L} \alpha_l \sum_{j=1}^{T} a_{ij} f_l(t_j) \le p_i$$

Portfolio Cashflows

- Simple version:
  - Set all cashflows = 1
- More advanced:
  - Choose set of cashflows that make objective function equally sensitive to changes in yield curve at all points
  - Set cashflows: $S_j = [jd(t_j)]^{-1}$
  - Iterations are needed to compute the values of s and find the efficient bonds (normally only two or three).

Curve Building Step by Step

- Use LP to select the efficient bonds for given tax bracket
- This will produce a relatively small number of bonds
- Include some slightly less efficient bonds to fill out the curve
  - Use bonds which are “relatively efficient”
- Apply basis splines & fit regression model

Relative Efficiency

- Define the Relative Efficiency of a bond for a given tax bracket as:
  - NPV of Cash flows / Bond Price
- Define a tolerance level (e.g. 99%)
- Include bonds with:
  Relative Efficiency > Tolerance

Lab: Pencoa Fund Management

- Scenario:
  - Running private client bond fund
  - Customers in different tax brackets (0%, 25%, 50%)
- Analyze market and recommend suitable purchases for different tax clienteles
- Worksheet: Pencoa Fund Management
  - See Lab and Solution Notes

Solution: Pencoa Fund Management 25% tax rate