LIUC

Università Cattaneo

International financial markets

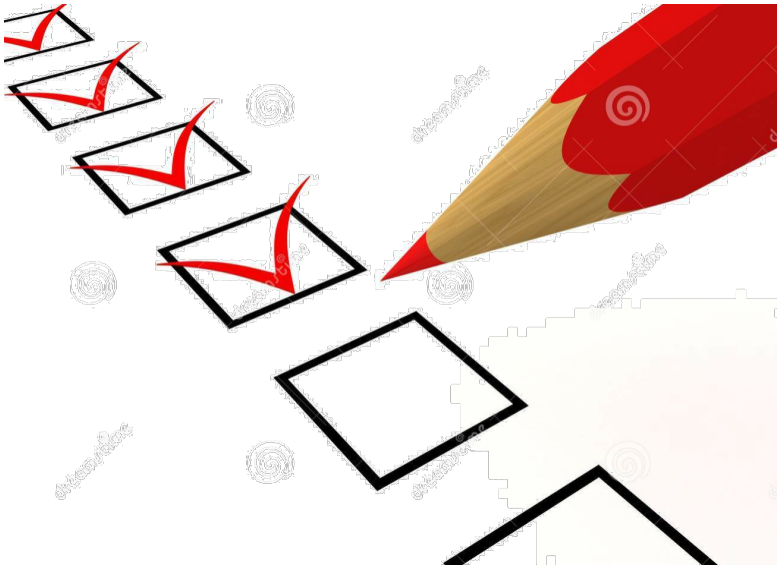
Interest rate risk

Luigi Vena

March 7, 2019

Today's agenda

- **Interest rate risk**
- Managing interest rate risk
- Duration
- Duration and risk



Mishkin, Eakins – ch. 3, 4 and 5

Finance Dictionary

Short Sale:

- An arrangement with a broker to borrow and sell securities.
- The borrowed securities are replaced with securities purchased later.
- Short sale let investors earn profits from falling securities prices.
- If prices increase, profits fall;
- On the contrary profits grow up when prices fall.

Interest Rate Risk

Years to Maturity	Yearly Coupon	Price @2%	Price @5%	Price @8%	Price @12%
1	0	98.0392	95.2381	92.5925	89.2857
2	7.5	110.6786	104.6485	99.1083	92.3947
5	7.5	125.9240	110.8237	98.0036	83.7785
10	7.5	149.4042	119.3043	96.6449	74.574
20	7.5	189.9329	131.1555	95.0909	66.387
30	7.5	223.1805	138.4311	94.3711	63.7516

Face Value = 100

Interest Rate Risk

- A rise in interest rate is associated with a fall in bond prices.
- On the contrary, a fall in interest rates is associated with a rise in bond prices.
- The more distant a bond's maturity, the greater the size of price change associated with an interest rates change.
- The more distant a bond's maturity, the lower the rate of return that occurs as a result of the increase in interest rates.
- Even though a bond has a substantial interest rate its return can turn out to be negative if interest rates rise.

Focus: yield to maturity, interest rate and return

- **Yield to maturity**: is the interest rate that equates the present value of cash flows received from a bond with its value today
- **Rate of return**: how well a person does by holding a bond (or another financial instrument) over a particular time period
- The return on a bond will not necessarily equal the interest rate on that bond.
- The only bond whose return equals the initial yield to maturity is one whose time to maturity is the same as the holding period
- A rise in interest rates is associated with a fall in bond prices, resulting in capital losses on bonds whose time to maturity are longer than the holding period.

Interest Rate Risk

- Suppose the following ZCB
  - Time to maturity: 5 years
  - Price: 920
  - Face Value: 1000
  - Suppose the all market interest rates are constant
- Which is the expected rate of return of such a ZCB?
- Which is the actual rate of return if one year after the interest rate rises to 2.6816%?

Interest Rate Risk

Years to Maturity	Yearly Coupon	delta -3%	delta +3%	delta +7%
1	0	2.94%	-2.78%	-6.25%
2	7.5	5.76%	-5.29%	-11.71%
5	7.5	13.63%	-11.57%	-24.40%
10	7.5	25.23%	-18.99%	-37.49%
20	7.5	44.82%	-27.50%	-49.38%
30	7.5	61.22%	-31.83%	-53.95%

Interest Rate Risk

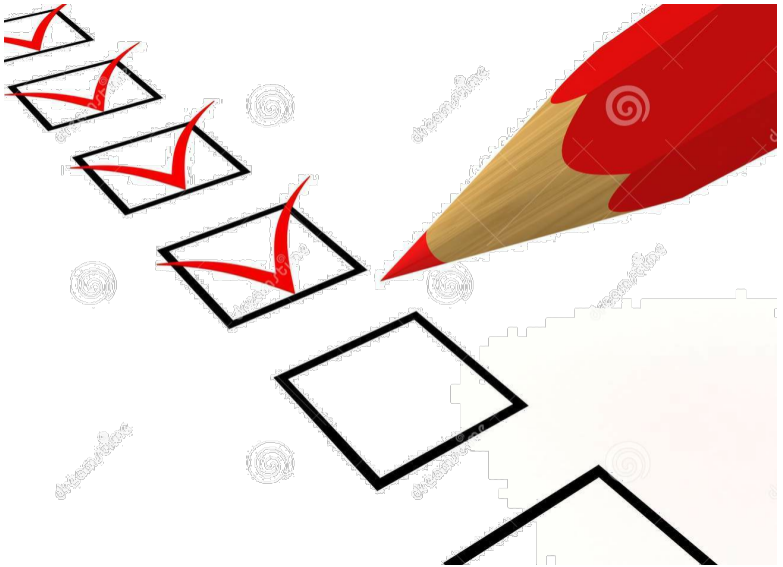
- Prices and returns for long-term bonds are more volatile tan those for shorter-term bonds.
- Price variation of +20% and -20% are common for bonds with more than 20 years away from maturity.
- The riskiness of an asset's return resulting from interest rates changes is so important that it has been given a special name, **interest rate risk**.
- Short term bonds have low interest rate risk.
- On the contrary, long term bonds have substantial interest rate risk, as their prices change radically when interest rates vary.

Interest Rate Risk

- In order to measure interest rate risk, financial managers need more precise information on the actual capital gain/loss that occurs when interest rate changes by a certain amount.
- That is to say, the price variation due to a certain variation in interest rates level.
- Moreover, the only maturity does not give too much information on the interest rate risk: two bonds with same maturity can have extremely different sensitivity to interest rates.
- To do this, managers need to make use of the concept of **duration**.

Today's agenda

- Interest rate risk
- **Managing interest rate risk**
- Duration
- Duration and risk



Mishkin, Eakins – ch. 3, 4 and 5

Income Gap Analysis

- **Income Gap Analysis**: measures the sensitivity of a bank's current year net income to changes in interest rate.
- The first step is for the risk manager to decide which assets and which liabilities are rate-sensitive:
  - which assets and liabilities have an interest rate that will be reset within a certain period
- Let us consider the 1y gap of First National Bank

Income Gap Analysis: Determining Rate Sensitive Items for First National Bank

Assets

- Cash items
- Securities
  - Less than 1 year
  - Greater than 1 year
- Residential mortgages
  - Variable rate
  - Fixed rate (greater than 1 year)
- Commercial loans
  - Less than 1 year
  - Greater than 1 year
- Physical capital

Liabilities

- Deposits
- CDs
  - Variable rate
  - Less than 1 year
  - Greater than 1 year
- Borrowings
  - Variable rate
  - Less than 1 year
  - Greater than 1 year
- Bank capital

Income Gap Analysis – I case

Risk Sensitive assets	Risk Sesnsitive Liabilities
Other Assets	Other Liabilities

Example: null gap. *Gap = 0*

Risk Sensitive Assets – Risk Sensitive Liabilities = 0

A null gap (=0) indicates that, whatever will be the interest rate variation, the net effect on banks income will be zero.

Income Gap Analysis – II case

Risk Sensitive Assets	Risk Sensitive Liabilities
Other Assets	Other Liabilities

Example: positive gap. *Gap > 0*

Risk Sensitive Assets – Risk Sensitive Liabilities > 0

Should the interest rate level rise, the bank may register an increase in the net income: new (higher) interest on assets more than cover new (higher) interest on assets.

Income Gap Analysis – III case

Risk Sensitive Assets	Risk Sensitive Liabilities
Other Assets	Other Liabilities

Example: negative gap. *Gap < 0*

Risk Sensitive Assets – Risk Sensitive Liabilities < 0

Should the interest rate level rise, the bank may register a decrease in the net income: new (higher) interest on assets less than cover new (higher) interest on assets.

Income Gap Analysis – example

Assets		Liabilities	
Cash	5	Deposits (1y)	40
Short term loans (1y)	50	Deposits (5y)	50
Loans (2ys)	25	Short term debt (1week)	40
ZCB (3 months)	30	Fixed-Coupon bond (5ys)	30
ZCB (6 months)	75	ZCB (3 months)	60
Fixed-Coupon bond (3ys)	20	ZCB (18 months)	60
Fixed-rate mortgages (10ys)	50	Equity	20
PP&E	45		
Total assets	**300**	**Total Liabilities**	**300**

Income Gap Analysis

Recap:

Gap	*ΔR*	*Δ int. receiveable*		*Δ int. payable*	*Δ income*
> 0	↑	↑	>	↑	↑
> 0	↓	↓	>	↓	↓
< 0	↑	↑	<	↑	↓
< 0	↓	↓	<	↓	↑

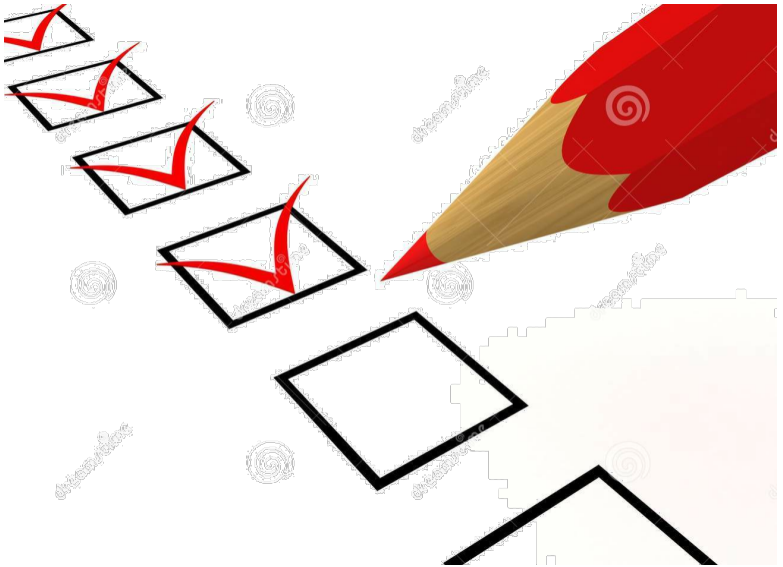
Interest Rate Risk – A speculative approach

The interest rate risk exposure may be ‘‘actively’’ managed: if I expect a certain variation in interest rate levels…

Expected ΔR	Gap changes	
Increase	Enlarge a positive gap	Reduce a negative gap
Decrease	Reduce a positive gap	Enlarge a negative gap

Today's agenda

- Interest rate risk
- Managing interest rate risk
- **Duration**
- Duration and risk



Mishkin, Eakins – ch. 3, 4 and 5

Duration

- The Duration is the weighted average of the maturities of the cash payments.
- In other words, it is the average lifetime of a debt security's stream of payments.

$$DUR = \sum_{t=1}^{n} \frac{t * \frac{CF_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}}$$

Duration

- Given that:

$$\sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} = P$$

- The formula for the duration can be rewrited as:

$$DUR = \sum_{t=1}^{n} \frac{t * \frac{CF_t}{(1+r)^t}}{P}$$

Duration

Exercise

- Compute the duration of the following bonds:
  - ZCB with constant r=5%, Face Value=100, and maturity 3 years;
  - Coupon bond with constant r=5%, C=3 (coupon frequency = annual), Face Value=100, 3 years to maturity.
  - Coupon bond with constant r=5%, C=15 (coupon frequency = annual), Face Value=100, 3 years to maturity.

Duration

- The formula for the duration is not so intuitive.
- However it can be easily programmed into a calculator or computer.
- All else being equal:
  - the longer is the term to maturity of a bond, the longer is its duration.
  - when interest rates rise, the duration of a coupon bond falls.
  - the higher the coupon rate on the bond, the shorter the bond's duration.
- The duration of a portfolio of securities is the weighted average of the durations of the individual securities, with the weights reflecting the proportion of the portfolio invested in each.

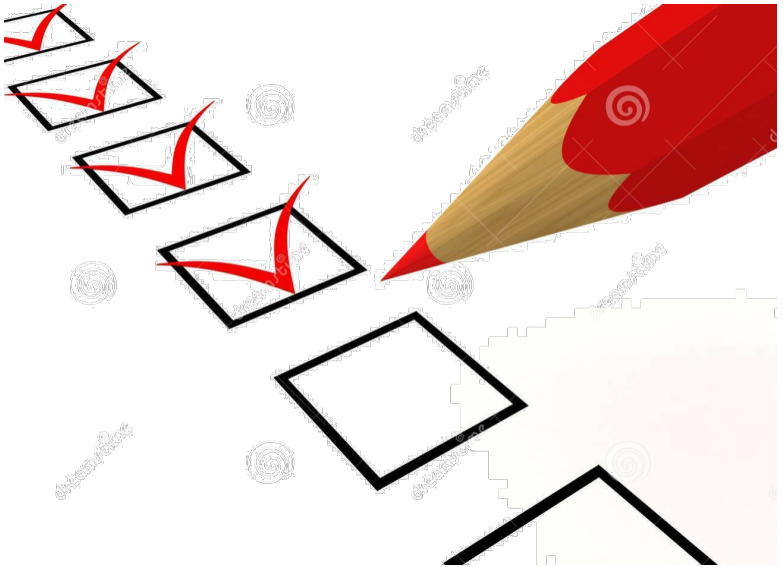
Duration

Years to Maturity	Yearly Coupon	DUR @2%	DUR @5%	DUR @8%	DUR @12%
1	0	1.00	1.00	1.00	1.00
2	7.5	1.93	1.93	1.93	1.93
5	7.5	4.43	4.39	4.34	4.28
10	7.5	7.90	7.62	7.33	6.92
20	7.5	13.44	12.09	10.74	9.05
30	7.5	17.98	14.98	12.28	9.43

Face Value = 100

Today's agenda

- Interest rate risk
- Managing interest rate risk
- Duration
- **Duration and risk**



Mishkin, Eakins – ch. 3, 4 and 5

Duration and Interest Rate Risk

- Knowing how the duration can be computed, it is now time to see how it can be used to measure the interest rate risk.
- Duration is a particularly useful concept as it provides a good approximation, especially when interest rate changes are small, for how much the security price changes for a given change in interest rates.
- More precisely:

$$\%\Delta P \approx -DUR * \frac{\Delta i}{1+i}$$

Duration and Interest Rate Risk

- The greater the duration of a security, the greater the percentage change in its market value for a given change in interest rates.
- The greater the duration of a security, the greater its interest rate risk.
- This reasoning applies equally to portfolio of securities.
- Duration of ZCB equals the time to maturity.
- Being equal the maturities of two bonds, the higher the coupon rate, the lower the duration.

$$0 \leq DUR \leq Time\ to\ maturity$$

Duration and Interest Rate Risk

Consider the following coupon bond:

- Time to maturity: 3 years
- Annual coupon rate: 5%
- Constant interest rate: 3.5%
- Face Value: 100

Suppose that the interest rate rise to 4.1%. Which is the correspondent price variation?

Show it, by using the duration and by discounting the CFs at the new interest rate.

Duration and Interest Rate Risk

Calculate the duration of the following coupon bond:

- Time to maturity: 3 years
- Annual coupon rate: 6%
- Constant interest rate: 7%
- Face Value: 1,000

Calculate the expected price change if interest rates drop to 6.75%, using the duration approximation

Calculate the actual price change using discounted cash flow.