

# QF609 Risk Analysis

## Lecture Notes 1

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## Main topics:

- Financial Institutions (FIs)
- Risks of FIs
- Risk Analysis and Management
- Financial Accounting Methods
- Interest Rate Risk I: Repricing Model

# Financial Institutions (1)

## Examples of FIs

- **Depository institutions:** banks, savings institutions, and credit unions etc.
- **Non-depository institutions:** insurance companies, securities firms, investment banks, finance companies, and mutual funds etc.

## What happens if there are no FIs?

Fund flows directly from households to corporations, but likely with a low level of flows:

- high monitoring costs
- poor liquidity (long-term nature of corporate equity/debt, lack of secondary markets)
- price risk

# Financial Institutions (2)

## Functions of Fls

- Brokerage:
  - acting as an agent providing information and transaction services
  - cost reduction with economies of scale
- Asset Transformer
  - purchase primary securities (equities, bonds, and other debt instruments) from corporations by financing through selling financial claims (secondary securities) to households
  - financial products sold to investors by Fls effectively allow for transformation of financial risks

*How can Fls profitably achieve financial risk transformation?*

- Fls, as a single delegated monitor, lower information cost
- Fls produce better and more timely information by issuing proper secondary securities, e.g. short term bank loans.
- Fls reduce information imperfection and asymmetry between investors and corporations

# Financial Institutions (3)

- secondary claims sold to investors are liquid and of low price risk (due to FIs' ability to diversify portfolio risks)

## Other Functions of FIs

- Maturity intermediation
- Transmission of monetary policy
- Credit allocation
- Intergenerational wealth transfers or time intermediation
- Payment services
- Denomination intermediation

## Categories of Fls

- Depository institutions
- Finance companies
- Securities firms and investment banks
- Mutual funds and hedge funds
- Insurance institutions

# Financial Institutions (5)

## Depository institutions

- The largest depository institutions are commercial banks, which accept deposits and make consumer, commercial and property loans.
- composition of commercial banking sector:
  - community banks: retail or consumer banking
  - regional and super-regional: various wholesale banking activities - residential lending, commercial and industrial lending, both regionally and nationally
  - money center banks: commonly referred to large banks which typically raise funds from domestic and international money markets instead of depositors, e.g. JP Morgan, Citibank, Deutsche Bank etc.. Their borrowing and lending activities mainly with governments, large corporations, and other banks
- mix of very large banks with very small banks
  - shrinking number of banks, mainly a result of M&A
  - consolidation has created some large banks and has reduced asset share of small banks
  - operating characteristics and profitability differ across size classes

# Financial Institutions (6)

- large banks have focused more on off balance sheet (OBS) activities:
  - an item is an OBS asset /liability if, when a contingent event occurs, the item moves onto the asset/liability side of the balance sheet or an income/expense item is realized on the income statement
  - Examples of OBS activities:
    - letters of credit, loan commitments, loan and security issuance, check clearing, trust services etc.
    - derivative transactions - futures, forwards, options, and swaps
  - Under current accounting standards, such activities are not shown on the current balance sheet. By moving activities off the balance sheet, banks hope to earn additional fee income to complement declining margins or spreads on their traditional lending business, while avoid regulatory costs or “taxes” since reserve requirements and deposit insurance premiums are not levied on off-balance-sheet activities



# Financial Institutions (7)

- large banks rely on factual financial information, computer models, and centralized decision making as the basis for conducting business.
- small banks focus more on relationship banking, often basing decision on personal knowledge of customer's creditworthiness and an understanding of business conditions in the community they serve.

## Risks of commercial banks

- banks are highly leveraged: i.e. a large percent of assets are funded by debt (equity to assets ratio at 11.26% as of 2015), where the risk is that the return on assets may not be sufficient to cover interests on debt
- loans: credit risk, interest rate risk
- deposit: interest rate risk, liquidity risk
- OBS activities: market risks with derivative positions
- operational risks: system failure, process failure, human errors etc..

# Financial Institutions (8)

Ranking	Bank	Asset Size in USD Billion, as of 2021
1	 Industrial and Commercial Bank of China Limited	5,537
2	 China Construction Bank	4,762
3	 Agricultural Bank of China	4,576
4	 Bank of China	4,207
5	 JPMorgan Chase	3,744
6	 Mitsubishi UFJ Financial Group	3,177
7	 Bank of America	3,170
8	 HSBC	2,954
9	 BNP Paribas	2,906
10	 Credit Agricole	2,674

\* source: [https://en.wikipedia.org/wiki/List\\_of\\_largest\\_banks](https://en.wikipedia.org/wiki/List_of_largest_banks)

# Financial Institutions (9)

Assets			
Loans and securities			\$11,722.4
Investment securities		\$3,953.0	
U.S. government securities	\$2,015.3		
Other	1,937.7		
Total loans		7,769.4	
Interbank loans	94.8		
Loans excluding interbank	7,674.6		
Commercial and industrial	\$1,737.6		
Real estate	3,801.9		
Individual	1,301.2		
All other	945.9		
Less: Reserve for loan losses	112.0		
Total cash assets			1,770.0
Other assets			1,186.8
Total assets			14,679.2
Liabilities			
Total deposits			\$11,108.4
Deposits held in foreign offices		\$1,345.9	
Deposits held in domestic offices		9,762.5	
Transaction accounts	\$1,750.5		
Nontransaction accounts	8,012.0		
Borrowings			1,578.2
Other liabilities			339.1
Total liabilities			13,025.7
Total equity capital			1,653.5

\* balance sheet (all U.S. commercial banks) as of 2015, in USD Billions.

\* source: [www.fdic.gov](http://www.fdic.gov)

## Other depository institutions

- saving institutions: saving and loans associations, saving banks (similar to commercial banks, but are geared toward serving individuals rather than businesses)
- credit unions: nonprofit institutions owned by member depositors

## Finance Company

- similar to banks, main activity is lending
- no depository function - main source of funding is short term commercial paper (i.e. unsecured/short-term debt issued by corporations) and long term parent and other debt (e.g. debt Ford Motor Credit Corp owed to Ford Motor Corp.)
- generally riskier customers than banks
- generally lower leverage than banks

# Financial Institutions (12)

Company Name	Total Receivables (\$ millions)	Type of Finance Company	Ownership
Ally Financial	\$105,173	Sales finance	NYSE-listed independent
American Express	18,401	Personal credit	NYSE-listed independent that also owns American Express Bank
Bank of America (credit card business)	98,445	Personal credit	Part of Bank of America
Capital One Financial	88,726	Personal credit	NYSE-listed independent that also owns Capital One Bank
CIT Group	20,448	Business credit	NYSE-listed independent
Citigroup (credit card business)	134,109	Personal credit	Part of Citigroup
Discover Financial Services	68,335	Personal credit	NYSE-listed independent
Ford Motor Credit Company	85,699	Sales finance	Captive of Ford
General Electric Capital Corporation	78,064	Sales finance and business credit	Captive of GE
HSBC Finance Corp.	19,475	Personal credit	Subsidiary of HSBC Holdings
J.P. Morgan Chase (credit card business)	126,979	Personal credit	Part of J.P. Morgan Chase
Synchrony Financial	63,520	Personal credit	NYSE-listed independent

\* *Largest finance companies, as of 2015*

## Securities brokerage firms and investment banks

- Investment banking: underwriting and distributing new issues of (IPOs) and secondary issues of debt and equity
- Venture capital: professionally managed pool of money used to finance new and often high risk firms, demand high return and easy exit when need to.
- securities services : assistance in the trading of securities in the secondary markets (brokerage services and/or market making)
- corporate services: advising on M&A and restructuring of corporations
- investing and trading: position trading, pure arbitrage, risk arbitrage, program trading
- cash management
- Back-office and other service functions: security clearance and settlement, research and other advisory services such as on divestitures and asset sales.

## Mutual Funds

- pool the financial resource of individuals and companies and invest in diversified portfolios of assets
- provide opportunities for small investors
- types of mutual funds:
  - money market funds (MMFs): short term securities (short term nature)
  - long term funds: bond funds, equity funds, hybrid funds (long term nature)
- the most closely regulated among nondepository FIs



## Hedge Funds

- funds solicit funds from wealthy individuals and other investors (commercial banks) and invest on their behalf
  - not subject to SEC regulation prior to 2010
  - remains less regulated than mutual funds - exempt from SEC registration requirement if: 1) fewer than 100 investors 2) investors are "accredited" 3) sold only via private placements
  - common feature is use of leverage
- Offshore hedge funds: regulated in host country where rules are typically not burdensome and provide anonymity to fund investors and provide tax advantages

## Insurance Companies

- 2 major groups:
  - life insurers (longer term)
  - property & casualty insurers (short term)
- also sell life insurance/retirement products embedded with financial risks
- facing increasing competition from other FIs which also sell insurance and investment products.
- reinsurance companies: provide insurance against loss for primary insurance companies and reduce the impacts of large claims on them, hence expanding the business capacity of the primary insurance companies

# Financial Institutions (17)

**TABLE 2-1B** Products Sold by the U.S. Financial Services Industry, 2016

Institution	Function							
	Payment Services	Savings Products	Fiduciary Services	Lending		Underwriting Issuance of		Insurance and Risk Management Products
				Business	Consumer	Equity	Debt	
Depository institutions	X	X	X	X	X	X	X	X
Insurance companies	X	X	X	X	X	X	X	X
Finance companies	X	X	X	X	X	†	†	X
Securities firms	X	X	X	X	X	X	X	X
Pension funds		X	X	X				X
Mutual funds	X	X	X					

# Risks of Financial Institutions (1)

Generally speaking, risk refers to the degree of uncertainty and potential financial loss that can arise from FIs' business running. Below is a list of the common risks facing FIs:

- interest rate risk, credit risk, liquidity risk, foreign exchange risk, market risk, country or sovereign risk, operational risk, insolvency risk, model risk etc.

A few remarks:

- The risks above are not unique to FIs many of which are also faced by other global firms.
- the interest rate risk above refers to potential financial losses driven by interest rate changes as a result of mismatch of assets and liabilities from a balance sheet perspective, even though interest rate risk can also arise from other OBS activities and trading book positions in the case of a bank.

# Risks of Financial Institutions (2)

## Interest Rate Risk

Risk of potential net interest income losses a result of mismatch of assets & liabilities and changing interest rate environments:

- refinancing risk
- reinvestment risk
- balancing hedging or asset and liabilities matching is inconsistent with FIs' role as an asset transformer (e.g. transformation of short term deposits into long term debts)

## Credit Risk

Risk that promised cash flows on financial claims held by FIs, such as loans or bonds, will not be paid in full:

- **systematic credit risk**: the risk of default associated with general economy wide or macro conditions affecting all borrowers
- **firm-specific credit risk**: default of the borrowing firm attributing risk factors specific to the borrow firm
- trend of growing credit - credit card/C&I/property loans

# Risks of Financial Institutions (3)

## Foregin Exchange Risk

Risk that moves in foreign exchange rates can adversely affect the value of an FI's assets and liabilities denominated in foreign currencies, when considered in domestic currency terms.

- foreign investments enable FIs to expand abroad directly through branching or acquisitions or indirectly by building a financial asset portfolio that includes foreign securities.
- returns on foreign and domestic investment are not perfectly correlated:
  - two economies may have different focuses and growth rates
  - two FX rates are not perfectly correlated in general
- undiversified foreign exposure creates FX risk.

# Risks of Financial Institutions (4)

## Market Risk

Risk of losses incurred from securities and derivatives positions in an FI's trading book:

- depending on the traded instruments, the trading positions can be exposed to interest/FX/credit/commodity/equity and other asset price risks
- daily profit & loss (PnL) fluctuation due to day-to-day market movements of asset prices (trading book positions are typically marked-to-market for liquid instruments or marked-to-model for less liquid exotic instruments on a daily basis)
- market risks present whenever an FI takes an open or unhedged long or short position in securities or derivatives

# Risks of Financial Institutions (5)

## Liquidity Risk

Risk that an FI unable to meet its financial obligations on time without sustaining unacceptable losses:

- 2 types of liquidity risk:
  - **asset/market liquidity risk:** the risk that a market participant may not be able to execute a trade (e.g. for hedging) or to liquidate a position immediately when such requirements arise (fire sale prices)
  - **funding liquidity risk:** is the risk that a sudden surge in cash outflow may leave an FI in seeking funding to meet the requirements (higher costs)
- liquidity risk may generate bank runs (i.e. when many customers demand withdrawal of their money simultaneously) which can turn into a serious solvency problem  
(<https://corporatefinanceinstitute.com/resources/economics/bank-run/>)



## Country or Sovereign Risk

Risk that a foreign government may default on its debt (sovereign debt) or other obligations, or impose restrictions on repayments to foreigners:

- often lack usual recourse via court system
- past examples: Russia (1998) , Argentina (1998-2002), Greece (2009) etc.

## Operational Risk

Risk of losses resulting from inadequate or failed internal processes, human and system errors, or external events.

- losses due to operational risk can be magnified since they affect reputation and future potential.
- past examples:
  - loss of backup files by BOA
  - unsecured wireless network at TJX
  - Bernie Madoff
  - London Whale

More example can be found from the link below:

<https://www.risk.net/comment/5384771/top-10-op-risk-losses-of-2017-crisis-era-fines-abate>

# Risks of Financial Institutions (8)

## Insolvency Risk

Risk that an FI may not have enough capital to offset a sudden decline in the value of its assets relative to its liabilities:

- can be a consequence or outcome of one or more of the risks described above: interest rate, credit, liquidity, foreign exchange, sovereign, market etc.
- good illustrative examples at the link below:

*<https://ourmoneyus.org/how-banks-become-insolvent/>*

# Risks of Financial Institutions (9)

## Model Risk

Risk of potential adverse consequences from decisions based on incorrect or misused model outputs:

- **FRB SR 11-7:** a model refers to a quantitative method, system, or approach that applies statistical, economic, financial, or mathematical theories, techniques, and assumptions to process input data into quantitative estimates
- examples of models: market risk measurement models, behavioral models, derivative valuation models etc.
- with digitization and automation, even more models are being integrated into business processes, e.g. program trading utilizing machine learning or AI models
- model risks can lead to financial loss, poor business and strategic decision making, or damage of firm reputation
- increasing regulatory requirements on model risk managements
- a good discussion on this topic: [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2557213](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2557213)

## Interaction between Risks

- risks can interact with each other
- need to study inter-dependencies among risks
- Examples:
  - interest rate and credit risk
  - interest rate and FX risk
- critical in design of pricing models well as risk scenario analysis

# Risk Analysis and Management (1)

Risk analysis is the process of identifying risks, measuring risks, and developing strategies to manage the risks.

## Identifying Risks

This is to detect and recognize risks faced by an FI

- taxonomy-based risk identification
- top-down approach to identify an FI's largest risks
- bottom-up approach to identify a comprehensive list risks at the BU level
- expert judgment
- scenario analysis
- proper review and challenge processes to provide feedback on the outcomes

# Risk Analysis and Management (2)

## Measuring Risk

This is to quantify risk exposures for risk monitoring and reporting purposes:

- utilize mathematical models and tools to perform the measurement
- risk measurement allows an FI to assess the significance of the risks and decide the actions needed for each specific risk
- requires significant technology resources and good infrastructure as risk measurement models are typically data and computation intensive
- increasing requirements on risk measurement models for regulatory reporting, e.g.:
  - Value-at-Risk (VaR): basis for market risk regulatory capital for banks
  - CCAR: capital adequacy test required by US regulators for large banks and some non-bank financial companies

A key focus of this course to look at some of the quantitative approaches and tools used by FIs for measuring risks in practice.

## Risk Management Strategies

This is the operational process after quantifying risks of an FI:

- 4 general strategies: tolerate, transfer, treat, or terminate
- require well-defined standards and policies, expertise, and experience, to decide what are the appropriate strategies to be taken
- quick reaction and update of risk management strategies needed in a real business environment



# Risk Analysis and Management (4)

An effective risk management framework is vital to an FI. Some essential elements of a sound risk management framework:

- firm risk appetite and tolerance clearly defined and well understood by all firm individuals
- an effective management and organizational structure of the risk management functions with clear ownership of responsibilities
- a healthy risk culture with an emphasis on transparency, awareness, and personal responsibility through reporting, collaboration, discussion, escalation, and sharing of information.
- proper processes and procedures in place for risk monitoring, reporting, and control
- independent internal/external auditing of risk management policies and processes
- risk oversight committees, at both firm and business levels, to perform periodic comprehensive overview of firm risk profiles

## Some Representative Risk Management Functions in Banks:

### CRO Functions

Consist of dedicated teams for identifying/measuring/monitoring/reporting of risks across different risk classes and risk model development

- **market risk management:** risks of trading book positions, covering multiple asset classes (fixed income, equity, credit, commodity etc.), work closely with trading desks on a daily basis
- **non-traded risk (NTR) management:** risks of banking book positions, in particular IRRBB and liquidity risks
- **credit risk management:** counterparty credit analysis and due diligence, e.g. assigning and maintaining internal risk ratings, preparing credit reviews, and monitoring counterparty credit exposures etc..

# Risk Analysis and Management (6)

- **model risk management:** independent oversight including validation of all models used in the bank and compliance with the model use policies:
  - derivative pricing models used by trading desks
  - risk models used for risk measurements, e.g. Value-at-Risk (VaR) models for traded risk measurement, stressing testing models, behavioral models for IRRBB and liquidity risk measurements
  - models used for program and electronic trading
  - ...
- **risk analytics and technology:** risk quants develop and implement risk models with the support from a dedicated technology team
- **other functions:** e.g. operational/sovereign/legal risk management etc..

# Risk Analysis and Management (7)

## CFO Functions

- **product control:** ensuring complete, accurate and timely profit & loss (PnL) reporting, balance sheets and analysis for trading, lending, and treasury desks.
- **valuation control:** primary responsibility is to ensure that the bank's risk portfolios are fairly valued. The group sets independent pricing verification (IPV) and valuation adjustment policies, and also run and report the outcomes of IPV and valuation adjustments.
- **other functions:** finance, treasury...

## Internal Audit

- provide independent assurance that an organization's risk management, governance and internal control processes are operating effectively
- typically report to an audit committee appointed by the board

# Financial Accounting Methods (1)

There are 2 common accounting approaches used by FIs for P&L recognition over an accounting period:

- **Accrual Accounting (AA):** an accounting method whereby profits and losses are recognized on an accrual basis, i.e. revenues are recognized as they are "earned" as opposed to when they might be received in cash, and matched with associated costs.
- **Mark-to-Market (MTM) Accounting:** an accounting method whereby P&L are calculated based on fair values or current market values of assets and liabilities that reflect current market conditions.

We shall illustrate the concepts of these accounting methods using a simplified example.

# Financial Accounting Methods (2)

## Example

A bank has just been established with the following initial positions:

- an initial capital of \$20 billion raised from shareholders
- the capital is kept in an account with FRB
- \$100 billion of deposits is raised
- \$100 billion of loans is issued

The initial balance sheet will look like below:

Liabilities		Assets	
Capital	20	FRB	20
Deposits	100	Loans	100
	120		120

# Financial Accounting Methods (3)

Now, assume:

- both the loans and deposits have a fixed maturity, say 5Y
- 3% interest on the deposits and 5% interest on the loans, both paid annually
- the bank spends \$1 billion per year on staff and other costs
- assume no interests earned on capital deposited in FRB

If interests and expenses are transacted in cash, in a year's time, the bank will receive \$5 billion interest on loans, and pay \$3 billion interest on deposit and another \$1 billion expenses, leaving a net \$1 billion in cash:

Liabilities		Assets	
Capital	20	FRB	20
Retained profit	1	Loans	100
Deposits	100	Cash	1
	121		121

# Financial Accounting Methods (4)

Notes that:

- the \$1 billion net profit from interests and expenses is a liability to the bank's owner which gives rise to the "retained profit" item on the liability side, hence making the balance sheet "balanced"
- The capital and retained profit together now makes up the equity of the bank
- In reality, the bank is not likely to keep its net profit in physical cash, instead may be place it in FRB or lend it out as new loans

In this case, the year 1 P&L account of the bank can be presented as:

Interest received	5
Interest paid	(3)
<hr/>	
Net interest income	2
Operating expenses	(1)
<hr/>	
Net profit	1



## Financial Accounting Methods (5)

The simplified example above serves to illustrate how the quantity and mix of assets and liabilities, hence equity, on balance sheet change over time and how the P&L account can explain the equity change between two dates in terms of income and expenses items.

The example may suggest that a P&L is recognized only when cash payments occur. However, in reality, few business will produce accounts on a cash-only basis, e.g. a manufacturing business will recognize profit at the point of sale even if the goods are sold on credit (the increase in equity in this case can be balanced with an asset termed "debtors"), as long as there is no doubt on the debtors' ability and willingness to settle the bills.

This bring us to the key idea behind the method of **accrual accounting (AA)**:

- It is not the actual date on which a cash payment is received/paid that matters, but rather how much of the payment has been earned or accrued in the P&L period.

A slight modification of the example should make the idea clear.

# Financial Accounting Methods (6)

In the example earlier, let us instead assume that:

- the contractual interest on \$20 billion of the \$100 loan is paid every two year at 10% per 2-year while the interest on the remaining \$80 billion loan remains to be paid annually at 5%

Follow the very early approach (i.e. on a "realized cash" basis):

Year 1 BS				Year 2 BS			
Liabilities		Assets		Liabilities		Assets	
Capital	20	FRB	20	Capital	20	FRB	20
Deposits	100	Loans	100	Retained profit	2	Loans	100
				Deposits	100	Cash	2
120		120		122		122	

- Year 1: no net profit as only \$4 billion cash interest payments is realized from the loan which offset the interest cost and operating expense exactly
- Year 2: net profit =  $20 \times 10\% + 80 \times 5\% - 100 \times 3\% - 1 = 2$

# Financial Accounting Methods (7)

- The zero net profit on Year 1 BS does not seem to be a fair assessment of the underlying profitability considering the bank is overall making a 2 billion profit in the first two years.
- It may be more appropriate to smooth out that the impact of any timing differences of actual cash settlement dates in P&L terms, which is the key idea of **AA** - to accrue income and expenses evenly over the accounting period. With **AA**, we would have:

Year 1 BS				Year 2 BS			
Liabilities		Assets		Liabilities		Assets	
Capital	20	FRB	20	Capital	20	FRB	20
Retained profit	1	Loans	100	Retained profit	2	Loans	100
Deposits	100	Interest receivable	1	Deposits	100	Interest receivable	2
	121		121		122		122

The net interest receivable for Y1 is:

$80 \times 5\% - 100 \times 3\% - 1 + 20 \times 10\% \times \frac{1Y}{2Y} = 1$  where the last term is the accrued interest on the \$20 billion loan.

*Notes: for simplicity, we assume in above that interests do not get re-invested or re-financed and simply accumulated in the "Interest receivable" and "Retained profit" accounts.*

# Financial Accounting Methods (8)

**Exercise:** Assume again that both the loans and deposits pay interests annually (5% and 3% respectively), how would the BS look like in 3M?

## Remarks on AA:

- positions are assumed to be held to maturity, hence will not be sold in the normal course of business
- If a borrower's default becomes highly likely, an impairment provision should be made immediately that effectively reduces the asset value of the loan/bond, and on the liability side takes the estimated future loss out of the profit.
- Interests and expenses should be recognized on a backward looking accrual basis evenly over the life of the loan or deposit irrespective of actual interest receipts or payments to ensure stability of net interest income.
- AA is sometimes referred to as **book-value accounting** - assets and liabilities are reported at their original historical value which does not vary over time.

# Financial Accounting Methods (9)

**MTM Accounting:** The essential difference between an accrual approach and an MTM approach is that under the latter assets and liabilities are shown at their current market value. The net income each year is calculated as change of net realized cash plus change in net NPV of the BS positions: Let's illustrate the idea using the previous example, but with the additional assumptions below:

- no possibility of any credit losses
- discounting rates are 3% flat for all maturities (used for discounting) and remain the same in the 5 year period
- operating expenses are zero

T	1Y	2Y	3Y	4Y	5Y	Total
Net Realized Cash	2	4	6	8	10	—
NPV of Loan	107.43	105.66	103.83	101.94	100.00	—
NPV of Deposit	-100.00	-100.00	-100.00	-100.00	-100.00	—
MTM	9.43	9.66	9.83	9.94	10.00	—
Net Profit (MTM)	9.43	0.22	0.17	0.11	0.06	<b>10.00</b>
Net Profit (Accrual Accounting)	2	2	2	2	2	<b>10.00</b>

## Remarks:

- Under both accounting approaches, the total amount of net income over the 5 year period is the same (\$10 billion), but the distribution differs radically
- The AA approach recognizes the income evenly over the 5 year period (i.e. as they are earned over time), while the MTM approach realizes the vast bulk in the first year with the net incomes in subsequent years mainly capturing the compounding effect.
- In practice, discounting rates can change over time, hence may give rise to some volatility in the net income over time.
- Generally speaking, banks apply the AA approach apply mostly to **banking books** and the MTM approach to **trading books**.

## Trading Book

A trading book is one that comprise instruments held for one or more of the following purposes:

- short-term re-sale
- profiting from short-term price movements
- locking in arbitrage profits
- hedging risks that arise from the above

## Banking Book

A banking book can be defined as one that consists of positions that are not in the trading book. Generally speaking, it consists of the positions on a bank's balance sheet that are expected to be held to maturity, typically consisting of customer loans to and deposits from retail and corporate customers. It can also include those derivatives that are used to hedge exposures arising from the banking book activities, including interest rate risk.

# Interest Rate Risk I: The Repricing Model (1)

## The Repricing Model

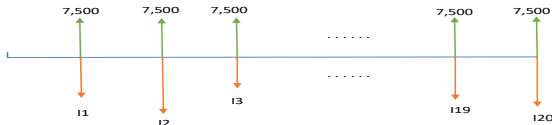
- This is a model widely used for measuring interest rate risks in banking books (IRRBB) positions and is also recommended by Bank of International Settlements (BIS) for the calculation of some IRRBB risk metrics.
- **Repricing** refers to the nearest future interest rate update/fixing event associated with a financial claim which can be a result of:
  - a contractual interest rate fixing for an instrument payment
  - a rollover/renewal of an expiring instrument or a partially retiring balance of an instrument
- A repricing is defined by 2 attributes:
  - **repricing gap**: notional exposure or book value of the contract subject to repricing: positive (resp. negative) for asset (resp. liability).
  - **repricing date**: date on which the interest rate get "repriced" (effectively, fixed)



# Interest Rate Risk I: The Repricing Model (2)

To study some of the repricing examples, let us introduce the basic mechanics of the following instruments.

- **Interest Rate Swap (IRS):** E.g. notional = \$1 million, maturity = 5Y, pay/received quarterly, receive fixed leg at 3%, pay 3M Libor (fixed in advance), no notional exchange.
  - fixed leg payment is flat at  $1,000,000 \times 3\% \times 0.25 = 7,500$
  - float leg payment varies depending on the Libor fixing (fixed at the beginning of the period): so  $I_k = 1,000,000 \times LIBOR_k \times 0.25$



# Interest Rate Risk I: The Repricing Model (3)

- Fixed Rate Mortgage: E.g. notional = \$1 million, maturity = 20Y, monthly payment, rate = 4%
- Floating Rate Mortgage: E.g. notional = \$1 million, maturity = 20Y, monthly payment, inception rate = 4%, rate adjusted every 6-month.

Will do a simple demonstration of the payment patterns of the above on EXCEL (will get TA to upload it to course site).

# Interest Rate Risk I: The Repricing Model (4)

## Examples:

Product	Interest Rate	Notional	Maturity	repricing date	repricing gap	notes
Interest-Only Loan	3%	\$1 million	5Y			
Interest-Only Loan	USD 3M Libor	\$1 million	5Y			
Deposit	3%	\$1 million	1Y			
Deposit	USD 3M Libor	\$1 million	1Y			
Treasury bill	4.5%	\$1 million	3M			
Treasury notes	4%	\$1 million	6M			
Treasury notes	3.8%	\$1 million	10Y			
Mortgage	rate adjusted every 6M inception rate = 4%	\$1 million	20Y			
Mortgage	flat rate at 4% flat	\$1 million	20Y			
IRS pay	3%	\$1 Million	10Y			
IRS receive	USD 3M Libor	\$1 Million	10Y			
1M-forward starting deposit	3%	\$1 million	1Y			
1M-forward starting deposit	USD 3M Libor	\$1 million	1Y			
1M-forward starting IRS pay	3%	\$1 Million	10Y			
1M-forward starting IRS receive	USD 3M Libor	\$1 Million	10Y			
1M-forward starting IRS pay	10Y par swap rate quoted in 1M	\$1 Million	10Y			
1M-forward starting IRS receive	USD 3M Libor	\$1 Million	10Y			

# Interest Rate Risk I: The Repricing Model (5)

## Notes:

- The concept of repricing date is relatively intuitive while repricing gap can be thought of as the book value of the transaction on the repricing date (An IRS may be less trivial from this perspective). That's why the repricing model is regarded as a book value based approach.
- In all examples above, we assume that the positions are newly established. In practice, many positions with the bank are legacy, whose repricing date can be any fractional tenor. E.g. for a 5Y fixed rate deposit, what will be its repricing date after 7M?
- In practice, a bank will fix a set of standardized repricing tenors for their interest gap reporting (some banks may have a well established infrastructure which allow them to compute the gap report with daily repricing grids). With repricing grids 1D, 3M, 6M, ..., for example, if the next repricing date for a transaction is in 2M, it will get allocated to the 3M bucket.

# Interest Rate Risk I: The Repricing Model (7)

- An example format of an interest rate gap report produced by banks is shown below. The sum of all repricing gaps on a give repricing date then gives the net repricing gap.

repricing date	Loans	Deposits	...	Net Gap	CGAP
1D	2	-10	...	-10	-10
3M	5	-20	...	-10	-20
6M	6	-25	...	-15	-35
9M	10	-10	...	-20	-55
1Y	20	-5	...	10	-45
2Y	...	...	...	...	...
3Y	...	...	...	...	...
4Y	...	...	...	...	...
5Y	...	...	...	...	...
10Y	...	...	...	...	...
Total	...	...	...	...	...

# Interest Rate Risk I: The Repricing Model (8)

- The gap report on a particular date is typically a 2-dimensional table, one representing time to next repricing and the other representing the product category.
- The time-to-repricing buckets are usually standardized with more dense grids in the front end.
- The gap is constructed by calculating the repricing gap/date for each contract/position a bank has and slotting it into one of the grids on the report based on its repricing date and product type.
- The gaps allocated to the same grid are aggregated to give the net gap for the grid where a positive (resp. negative) grid arises when there are more (resp. less) assets repriced in the bucket than liabilities.
- The last column CGAP represents the cumulated gaps along the time bucket which give an indication of the overall gap risk.
- Once a gap report is produced, it can be used as an input for calculation of various risk metrics.

## Interest Rate Risk I: The Repricing Model (9)

- In the textbook, an asset subject to repricing is referred to as a risk-sensitive asset (RSA), respectively RSL for a liability subject to repricing, and both assumed to take a positive sign. For a given repricing date, the repricing gap is the net, RSA-RSL.
- One application of the repricing model is for computing **change in net interest income (NII)** under given interest rate changes. The change NII for a particular repricing bucket,  $\Delta NII_i$ , is in general given by:

$$\Delta NII_i = RSA_i \cdot \Delta R_i^A - RSL_i \cdot \Delta R_i^L$$

If  $\Delta R_i^L = \Delta R_i^A = \Delta R_i$ :

$$\Delta NII_i = GAP_i \cdot \Delta R_i = (RSA_i - RSL_i) \cdot \Delta R_i$$

- Clearly, an increase in interest rate generally results in a positive (resp. negative) impact on NII of RSAs (resp. RSLs). The net NII impact will depend on the RSA size relative to that of RSL, and the RSA rate increase relative to the RSL rate increase.

# Interest Rate Risk I: The Repricing Model (9)

While the repricing model is relatively simple, in its basic form, it also comes with some weaknesses:

- ignore interest rate effects on market values of assets and liabilities (a serious issue?)
- a gap report with wide repricing buckets may either exaggerate or hide risk positions.
- behavioural assumptions may need to be embedded into the repricing model to deal with contracts with balance amortization, prepayment, or early closure (e.g. mortgage)
- A gap report generally gives no indication of either any basis risk – items that appear to offset by virtue of having the same re-pricing date may not actually re-price by the same amount.