Risk Management Products to Financial Institutions
銀行風險管理

基本概念

金融機構經營將面對的風險包括了

-Interest Risk

-Foreign Exchange Risk

-Liquidity Risk

-Market Risk

-Operation Risk

金融機構可藉由不同的金融產品或投資組合策略來進行風險管理(或避險)，如：

(1) 面對 Interest Risk，可利用 Repricing (or funding gap) model、Maturity model 以及 Duration model 來進行風險控管

(2) 可利用衍生性金融商品(如 Futures、Forwards、Options、Caps、Floors、Collars)來進行風險控管

(3) 面對 Foreign Exchange Risk，可透過 on-balance sheet hedge 及 off-balance sheet hedge 二種策略來進行避險

(4) 對於 Liquidity Risk，可採取 Liability management 及 reserve asset management 二種策略進行風險管理

(5) 金融機構可採取 RiskMetrics、Historical simulation 及 Monte Carlo Simulation 或 BIS 等方式來衡量金融機構所面臨的 Market Risk

Interest Rate Risk

➢利率風險的潛在威脅

<Example> Savings and Loan Institutions (S&L)

—S&L 借短支長，以賺取利差

—1972~1982 間，短期利率>長期利率

當面臨 interest rate volatility 增加時，可透過 Repricing (or funding gap) model、Maturity model 以及 Duration model 三種方式來進行風險控管。一般來說，金融機構可藉由降低三種 Gap 來降低利率變動造成的衝擊。

1. Repricing model (or funding gap)

(1) Repricing Gap 的定義

The repricing gap is the difference between assets and liabilities whose interest rate will change during a particular time period.

(2)如何估計 Repricing Gap

➢依到期日長短切割數個 maturity buckets

➢依 reprice 期間長短將資產/負債分配到不同的 maturity buckets

ex：3-month T-bill is repriced every 3 months

2-year time deposits is repriced every 2 years

➢資產/負債以 book value (historical value)計算，而非 market value

➢equity capital 屬最長期負債

➢Gap = Asset – Liability (for each maturity bucket)

➢整個資產負債表的 Cumulative Gap (CGAP) = 0

➢ $\Delta NII_i = GAP_i \times \Delta R_i$

where

ΔNII_i：change in net interest income in the i bucket

GAP_i：gap between rate sensitive assets and rate sensitive liabilities in the i bucket

ΔR_i ：change in the interest rates affecting the i bucket

<Example >

Repricing Gap	Assets	Liabilities	**Gap**	**CGAP**
1 day	50	65	**-15**	**-15**
1 day ~ 3 months	40	45	**-5**	**-20**
3 months ~ 12 months	130	140	**-10**	**-30**
1 years ~ 5 years	80	55	**+25**	**-5**
Over 5 years	20	15	**+5**	**0**
Total	320	320		

<Example >

Calculate the repricing gap and the impact on the net interest income of a 1% increase in interest rates if rate-sensitive assets total $400million and rate sensitive liabilities total $300 million

(Ans) repricing gap = $ 400 m -$ 300 m = $ 100 m

ΔNII = $100 m x 0.01 = $1 m

<Example >

Calculate the banks 6-month cumulative gap

Asset		Liabilities	
Short term loans (1yr maturity)	15	Demand deposits	60
Long term loans (2yr maturity)	25	Passbook savings	55
3-month T-bills	10	3-month CDs	25
6-month T-notes	5	6-month CP	35
1-year T-notes	65	1-year time deposits	30
10-year T-bonds	75	2-year time deposits	25
15 year floating rate mortgage (repriced every 6 months)	50		
		Equity capital	15
Total	245	Total	245

Ans：

Total rate sensitive assets = 3 month T-bills+6 month T-notes+Floating rate mortgage

= 10 + 5 + 50

= 65

Total rate sensitive liabilities = 3-month CD + 6-month CP

= 25 + 35

= 60

CGAP = 65 – 60 = 5 million

<Example >

The fact that investors generally move funds out of demand deposits and into higher yielding instruments when rates rises suggests that demand deposits should be consider

(a) long term interest rate sensitive assets

(b) short term interest rate sensitive assets

(c) long term interest rate sensitive liabilities

(d) short term interest rate sensitive liabilities

(ps)有爭議的，因一般將 demand deposit 當成 core deposit

<Example >

Calculate the GAP Ration in the previous example

Ans：

$$GAP\_Ratio = \frac{CGAP}{Total\_Assets} = \frac{\$5million}{\$245million} = 2.04\%$$

(3) Repricing Gap 的優點

➢簡單

(4) Repricing Gap 的缺點

➢ignore market value effect：只考慮當利率改變時造成 income 的變動

➢over aggregative：在同一 bucket 中，資產/負債的現金流量可能不 match

➢doesn't deal with runoff：利率下滑時 mortgage 的提前償還金額增加

2. Maturity model

(1)基本概念

因 Repricing model 係採用 book value，因此忽略了利率變動造成 market value 的改變。一般而言，利率下跌，債券價格會上漲，不同到期日債券的價格變動幅度並不相同。如將銀行視為一群 rate-sensitive assets 及 rate-sensitive-liabilities 的投資組合，Maturity Gap 即為資產與負債的加權平均到期日之差距。

(2)利率變動與債券價格變動的關係

➢利率變動與債券價格變動反向

➢到期日(maturity)越長，利率變動造成的債券價格變動越大

➢隨到期日增加，利率造成的債券價格變動的幅度會減少

(3)如何計算 Maturity Gap

➢ $M_A = \sum_{j=1}^{N} W_{Aj} \times M_{Aj}$

where

M_A ： Weighted average maturity of a portfolio of n assets

W_{Aj} ： market value of asset j relative to the market value of the portfolio

M_{Aj} ： the maturity of asset j

➢ $M_L = \sum_{j=1}^{N} W_{Lj} \times M_{Lj}$

where

M_L ： Weighted average maturity of a portfolio of n liabilities

W_{Lj} ： market value of liability j relative to the market value of the portfolio

M_{Lj} ： the maturity of liability j

➢ Maturity Gap = M_A - M_L = the difference between the weighted average maturity of the banks assets and its liabilities.

(4)Maturity Gap 的缺點

➢未考慮現金流量的時點(即 duration)

➢未考慮銀行的財務槓桿程度

➢未考慮 reinvestment rate

<Example >

If interest rate rise, a bank with a negative maturity gap and positive equity capital will experience

(a) insolvency

(b) a gain in equity capital

(c) a loss of equity capital

(d) no change in equity capital

3. Duration model

(1)基本概念

Duration 考慮了現金流量的時點，因此較 Repricing model 及 Maturity model 更能表示利率變動對資產/負債造成的影響。

(2)如何計算 Duration Gap

➢ D_A ： weight average (based on market value) durations of assets

➢ D_L ： weight average (based on market value) durations of liabilities

➢ $\Delta E = \Delta A - \Delta L = -\left[D_A - (D_L \times k)\right] \times A \times \frac{\Delta R}{(1+R)}$

➢Leverage adjusted duration gap：$\left[D_A - (D_L \times k)\right]$

➢size of the financial institution： A

➢size of the interest rate shock：$\frac{\Delta R}{(1+R)}$

<Example >

A bank has the following balance sheet

Asset	Liabilities and Equities
Assets = 250 with duration = 12 years	Liabilities = 150 with duration=10 years
	Equity = 100
Total = 250	Total = 250

Calculate the change in equity if the interest rate increase from 7% to 8%

Ans：

k=150/250=0.60

$$\Delta E = -\left[(12-(0.60\times 10)\right]\times 250\times \frac{0.01}{0.07} = -14.02 million$$

<Example >

Determine the leverage ration necessary to immunize the balance sheet against changes in the interest rates, holding the asset and liability durations constant. Given Duration of assets is 10, and Duration of liabilities is 12.

Ans：

In order to set the leverage adjusted duration gap equal to zero,

$\left[D_A-(D_L\times k)\right]$=0

10-k*12=0

k=0.83

Futures and Forwards

1. Hedging 的概念

➢利率上揚，持有的價券價格下跌

➢選擇當利率上揚時，Futures 或 Forward 的價格會上漲

➢portfolio 受利率變動影響降低

➢當 portfolio 完全不受利率變動影響時，稱為 fully immunization

➢進行避險的同時，也放棄了 portfolio 可能的獲利

<Example 1>

Jane Swanson holds a 10-year, $10 million face value bond. The duration of the bond is 7 years. Suppose today the bonds have a market value of $98 per $100 face value. Swanson anticipates that interest rate will rise by 2% from current level of 5%.

(1)因利率上漲，Swanson 持有債券價格將下滑

$$\frac{\Delta P}{P} = -D \times \frac{\Delta R}{1+R}$$

$$\frac{\Delta P}{9{,}800{,}000} = -7 \times \frac{0.02}{1.05}$$

$$\Delta P = -\$1{,}306{,}667$$

(2)為避免損失，Swanson 在市場上賣出 3 個月後交割 10-year bond 的 forward，履約價為$98。

(3)3 個月後，利率上揚至 7%，10-year bond 價值下滑至$8,493,333 ($9,800,000-$1,306,667)

(4)Swanson 以市價$8,493,333 買進 10-year bond 來交割 forward

Spot		Forward	
Initial value	$9,800,000	Paid by forward buyer	$9,800,000
New value	$8,493,333	Cost of buying bond to deliver	$8,493,333
Loss	-$1,306,667	Profit	$1,306,667

(5)藉由賣出 forward 契約，Swanson 的投資組合並未受到利率上漲的影響

2. Microheding vs Macrohedging

(1)Microhedging：the process whereby a futures contract or other derivatives is used to *hedge a specific* asset or liability.

(2)Macrohedging：the process whereby a futures contract or other derivatives is used to *hedge the entire balance sheet duration gap*.

(3)Basis Risk：movement of spot asset's price is not perfectly correlated with the movement in the price of asset being hedged.

3. Routine Hedging vs Selective Hedging

(1)Routing Hedging：occurs when interest rate exposure is hedged by selling enough futures to offset the interest rate risk exposure of the cash positions of each asset and liability. Not all managers seek to do this since reducing risk could also reduce return.

(2)Selective Hedging：partially hedges the gap of individual assets and liabilities. Selective hedging can be used for interest rate risk, foreign exchange risk and credit risk.

4. Futures vs Forwards

(1)基本概念

	Futures	Forwards
交易場所	交易所	OTC
Mark-to market	Yes	No
契約格式	Standardized	Customized
Counterparty default		

(2)Hedge ratio

$$Hedgeratio = \frac{\Delta S}{\Delta f}$$

5. 利用 Futures/Forwards 來規避 credit risk

(1)credit forward：is used to hedge against a reduction in a borrower's credit quality after a loan has been issued and the loan rate is determined. A credit forward applies a credit spread on a benchmark bond issued by a bank borrower to compensate for possible default risk.

Credit Spread at End of Forward Contract	Credit Spread Seller (Lender)	Credit Spread Buyer (Insurance Company)
$S_T > S_F$ credit spread increase	Receive $(S_T - S_F) \times MD \times size$	Pays $(S_T - S_F) \times MD \times size$
$S_T < S_F$ credit spread decrease	Pays $(S_F - S_T) \times MD \times size$	Receive $(S_F - S_T) \times MD \times size$

Note：This forward contract has limited maximum loss

6. Futures Contract and Catastrophe Risk

- 提供產險業者進行巨災的避險，如 921 大地震
- payoff 與產險業者的 loss ratio 連結

Option, Caps, Floors, and Collars

1.利用 option 規避利率風險

(1)number of options need to buy

$$N_P = \frac{[D_A - kD_L] \times A}{\delta \times D \times B}$$

<Example 1>

Suppose a financial institution has assets of $10 million and liabilities of $9 million. The duration of its assets is 6 years, and the duration of its liabilities is 4 years. There is a put option available on a long-term T-bond. The delta of the option is 0.5, and the duration of the underlying bond is 7.73. The current value of $100,000 face value of long-term T-bond is &98,000. Calculate the number of put option contracts needed to hedge this position.

Ans：

$$N_P = \frac{[D_A - kD_L] \times A}{\delta \times D \times B} = \frac{[6 - (0.9x4)]x\$10{,}000{,}000}{[0.5x7.73x\$98{,}000]} = 63 contracts$$

2.利用 option 規避信用風險

(1)Credit Spread Call options：

- Definition：A credit spread's payoff is a function of the yield spread on a borrower's benchmark bond above the comparable T-bond rate.

- Payoff = max[(credit spread-exercise spread), 0] x nominal value
- if credit spread > exercise spread, the option is in the money, which means the default risk is increase
- if credit spread < exercise spread, the option is out of the money

(2)Digital default Option：

- Definition：A digital default option will pay a stated amount against the defaulted credit if the default happens.
- payoff = 0 if no default
- payoff = stated amount if default

3.利用 call-spread option 規避巨災風險(catastrophe risk)

產險公司可買進 Catastrophe (CAT)call spread option，以規避 loss ratio 大幅增高的風險

<Example 1>

Front Insurance Company buys a CAT call spread to hedge the risk that the loss ratio on this business may be somewhere between 90% and 120%

- Front 首先需支付購買 option 之 premium
- 若 loss rate < 90%，option payoff = 0
- 若 90%<loss rate<120%，option payoff = (loss rate-90%)x nominal value
- 若 120%<loss rate，option payoff = (loss rate-120%)x nominal value

  對 Front 而言，最高的保障只到 120%的 loss rate，超過部份需自行吸收

4.Caps, Floors, and Collars

(1)Cap(利率上限)

在市場利率走勢上揚時，以浮動利率舉債之企業，可支付權利金給賣方以購買利率上限契約，在合約有效期間內，如果雙方約定之市場指標利率高於所約定的利率上限，賣方須付利率差額給買方，如此買方可限制其浮動利率利息之成本負擔以降低利率風險。

(2)Floor(利率下限)

以浮動利率投資之企業，為規避利率下跌的風險，可購買利率下限契約，若雙方約定之市場指標利率低於所約定的利率下限，賣方須付利率差額給買方，如此買方可確保其以浮動利率計算利息之收益絕對不會低於契約的利率水準。

(3)Collar(利率上下限)

或稱為「利率區間」，當上限及下限並用時，當購買一利率上下限，意即買入一個利率上限並同時賣出一個利率下限。其可鎖定其利率波動之風險於上下限之間。可規避上揚的利率走勢 (利息成本不會超過上限)，然而倘若利息下跌時，客戶仍至少需負擔下限之利息成本。由於購入一利率上下限是等於買入一利率上限及賣出一利率下限，故其權利金費用較買入一利率上限為少，因而財務成本較低廉。

Foreign Exchange Risk

1. Source o Foreign Exchange Risk Exposure

(1) net exposure

$$net\_\exp osure_i = (FX\_assets_i - FX\_liabilities_i) + (FX\_bought_i - FX\_sold_i)$$

$$net\_\exp osure_i = net\_foreign\_asset_i + net\_FX\_bought_i)$$

- A positive net exposure position means that we are net long in a currency
- A negative net exposure position means that we are net short in a currency

2. On Balance-Sheet hedging

On Balance Sheet hedging is achieved when a financial institution has a matched maturity and currency foreign asset liability book.

<Example>

Assume the original exchange rate is USD1.70/CHF.

Assume the franc depreciate to USD1.55/CHF after 1 year.

Calculate net return of the bank.

Assets				Liabilities			
Amount (USD)	Currency	Yield	Maturity	Amount (USD)	Currency	Yield	Maturity
50 million	USD	8%	1 year	50 million	USD	6%	1 year
50 million	CHF	13%	1 year	50 million	CHF	10%	1 year

Ans：

(1)Assets：

- 50 million (in USD)的 Asset，一年後總價值為 50x1.08=54
- 50 million (in CHF)的 Asset，目前相當於 50/1.70=29.41CHF
  一年後可收到 13%的利息，總價值為 29.41x1.13=33.23CHF
  因 CHF 貶值，此部份資產總價值縮水至 33.23x1.55=51.51USD
- 一年後，總資產價值為 54+51.51=105.51，資產報酬率為 5.51%

(2)Liabilities：

- 50 million (in USD)的 Liabilities，一年後總價值為 50x1.06=53
- 50 million (in CHF)的 Liabilities，目前相當於 50/1.70=29.41CHF
  一年後需支付 10%的利息，總值為 29.41x1.10=32.35CHF
  因 CHF 貶值，此部份負債總價值亦降低至 32.35x1.55=50.15USD
- 一年後，總負債價值為 53+50.147=103.15，負債變動率為 3.15%

(3) Net return = average return on assets – average cost of funds

=5.51%-3.15%=2.37%

3. Off Balance-Sheet hedging

Rather than matching foreign assets with foreign liabilities, we may also hedge-off-balance-sheet by taking a position in the forward/future market while remain unhedged on the balance sheet.

4.Mulitcurrency Foreign Asset Liability Position

(1) Diversification 可能降低整體風險
(2) 利率及股價變動可能朝不同方向，使資產/負債價格有不同變動
(3) 整體避險較為複雜

Liquidity Risk

1. Causes of Liquidity Risk

(1)From Liabilities Side：

as depositors or policyholders demand payment

如：信用合作社發生擠兌現象

(2)From Assets Side：

cause bank has made loan commitment to borrowers.

2. Liquidity Risk of Commercial Banks and Thrift Institutions

(1)Liquidity Risk From Liabilities Side：

➢demand deposits is rather stable, forming the core deposits of the institution

➢銀行藉由歷史經驗或統計方法來估計每天的現金流量

➢擠兌將造成銀行的 liquidity risk

➢銀行透過 liability management 及 reserve asset management 二種方式因應

(2)Liquidity Risk From Asset Side：

➢可能的來源包括了 loan commitment, letters of credit 等

➢可透過 liability management, reserve asset management 及出售資產三種方式因應

(3)Gauging an institution's Exposure to Liquidity Risk：

➢Source of liquidity available

- cash equivalent, or very liquid assets(such as T-bill)
- Bank's borrowing ability of maximum amount that the bank may readily borrow from money or capital markets.
- Excess cash and reserves, defined as those exceeding required min amounts

➢uses of liquidity

- The amount of funds already borrowed from capital and money market
- Any borrowing from the Fed already outstanding

➢Comparing Peer Group Liquidity Ratios

- Liquidity Ratio = assets/liabilities
- 如銀行的 $\frac{illiquid\_assets}{short\_term\_deposit}$ 比值高，則 liquidity risk 較高
- 可利用銀行同業間的比較(peer group)來衡量相對 liquidity risk 高低

➢Fed 利用 liquidity index 來衡量銀行的流動性高低

- 假設"立即處份資產"，以折價幅度高低來衡量流動性
- $I = \sum_{i=1}^{N} \left[(w_i) \left(\frac{P_i}{\hat{P}_i} \right) \right]$

  where I ： liquidity index

  w_i ：proportion of each asset to the total assets

  P_i ：value(price)that can be realized if liquidated "immediately"

  $\hat{P}_i$ ：value(price)that can be realized from an orderly sale
- liquidity index 越高，表示銀行資產流動性高，立即處份資產時折價幅度小

<Example>

Assume that an institution has only 2 equally valued assets-a T-bill that ca be liquidated at its market value and a loan that can be liquidated at 90% of its value. The liquidity index value for the institution would be

(a) 50%

(b) 75%

(c) 90%

(d) 95%

➢Financial Gap 亦可衡量銀行流動性高低

- Financial Gap = average amount of loans – average amount of core deposit
- core deposit 屬穩定資金來源，Financial Gap 越高，流動性風險越高

3. Liquidity Risk of Life Insurance Companies

(1)通當壽險公司需維持一定水準的準備金來支付理賠金或解約金

(2)壽險公司亦可能遭到被保險人突然大量要求解約

如：1991 年，First Executive Corporation 爆發在操作高收益債券出現鉅額虧損的消息，使被保險人大量要求解約

(3)以 excess reserve 或出售資產來因應

4. Liquidity Risk of Property-Casualty Insurance Companies

(1)產險契約多較壽險契約短期—負債面

(2)產險公司多利用短期投資—資產面

(3)產險公司主要收入為保費(premium)，用以支付產險公司營運支出及理賠金

(4)若新契約銷售或 renewals 下降，保費收入隨之下滑，可能產生流動性風險

(5)重大意外事件(如 911)可能造成理賠金支出大增，生產流動性風險
(6)再保險機制

5. Liquidity Risk of Mutual Funds
(1)Closed-end fund 沒有 liquidity risk
(2)Open-end fund 在投資人大量要求贖回時，需賣股求現，亦是 liquidity risk

Market Risk

1. 為何需要衡量 market risk

(1)Management Information：衡量是否承擔過高風險

(2)Setting Limits：對不同交易員設定不同風險承擔度

(3)Resource allocation：將資產依風險報酬率高低配置

(4)Performance evaluation：依風險報酬率作為績效衡量指標

(5)Regulation：依風險高低計算最低資本適足要求

一般而言，衡量 market risk 可採用 internal model 及 Regulatory Model(即 BIS)

2.利用 internal model 衡量 market risk

(1)Risk Metrics：

即 variance/covariance model，可用以衡量 fixed income, foreign exchange 及 equities 的 market risk。

(2)Historical or Back Simulation Approach：

➢利用同一資產，過去 500 天的 return 當基礎

➢以過去 500 天中，表現最差的 5%為 VaR

➢優點

- 簡單
- 不需假設常態分佈
- 不需計算 correlation 或 standard deviation

(3)Monte Carlo Simulation Approach：

➢模擬多種未來可能的狀況

➢通常模擬 10,000 次，以第 500 個最大摸擬損失作為 VaR

3.利用 BIS standardized Framework 衡量 market risk

(1) Standardized Framework for fixed Income

➢General risk charge：reflect the product of the modified duration and interest rate shock anticipated for each maturity

➢Specific risk charge：measure the risk of a decline in the liquidity of the trading portfolio over the holding period

➢Disallowance factors：long and short position in different maturity zone are not offset perfectly (basis risk)

Zone	Disallowance factor
1 month – 12 month	40%
1 year – 4 years	30%
4 years – 20 years plus	30%

(2) Standardized Framework for Foreign Exchange

capital requirement = 8% of the higher of the aggregate long and short positions

(3) Standardized Framework for Equities

考量系統風險及非系統風險

- 系統風險 ： 8% of net long or short position
- 非系統風險： 4% of total position of a stock (long position + short position)