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Stress testing Credit, Market and Operational risk

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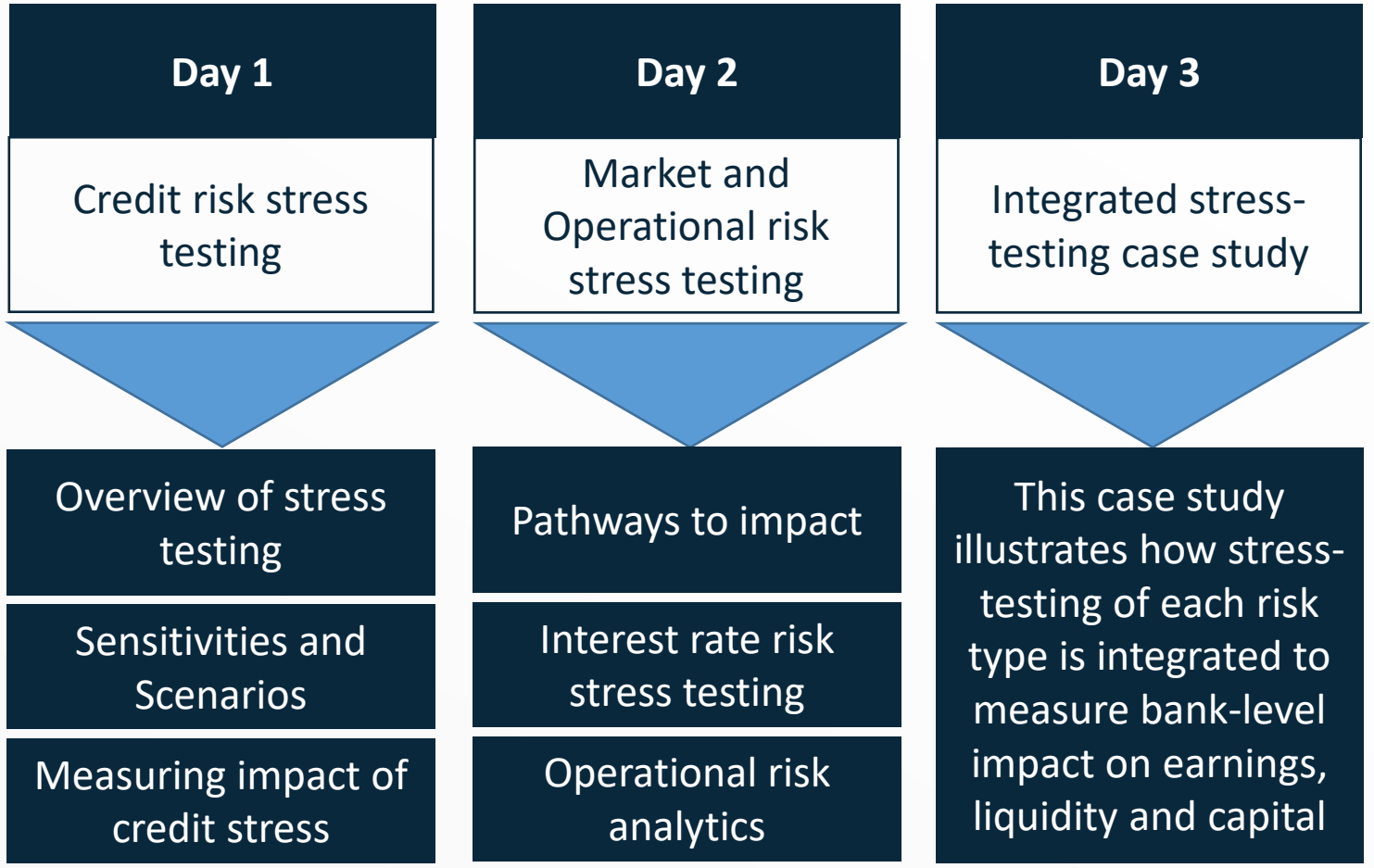
What is This Course About ?



Overview of stress testing

What is this part about?

- Overview of stress testing
  - What is stress testing?
  - Why do we need stress testing?
  - Where does stress testing fit into a bank's risk management framework?
  - How do we build informative stress scenarios?
- How do we integrate credit, market and operational risk stress tests to create an overall impact profile?
  - Bank-level factors
  - Market factors
  - Macro-economic factors

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Overview of stress testing

Stress testing is a technique to assess **vulnerability** to **exceptional** but **plausible** events impacting net earnings, equity value, and bank liquidity

Why do we need stress testing?

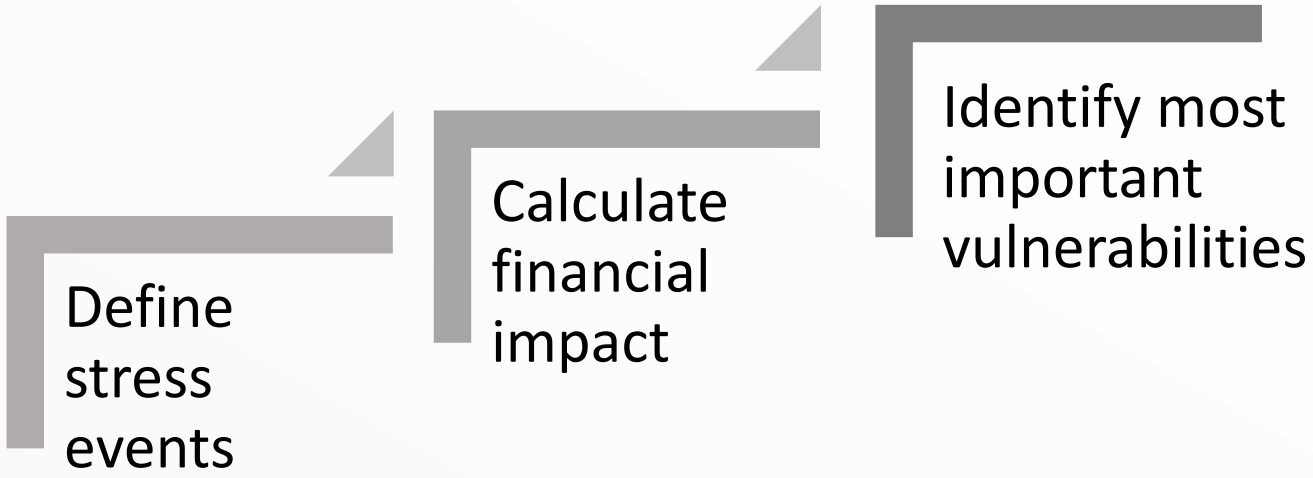
- Stress testing is used to assess vulnerability to decreased earnings, reduced capital adequacy, and insufficient liquidity on a forward-looking basis
- The objective is not to predict the future, but to assess whether the bank can withstand severe shocks
  - Vulnerabilities inform which shocks would cause problems and how
  - Identification facilitates establishing remedies ahead of possible shocks
  - A robust stress testing framework improves the bank's credit rating, which reduces funding costs
  - Stress testing complements other risk management techniques, e.g. VaR, to give a fuller risk picture (tails of the distribution)

Where does stress testing fit in?

- Stress testing is the *backbone* of the bank's ICAAP (Internal Capital Adequacy Assessment Process)
  - ICAAP is a regulatory requirement under Pillar 2 of Basel III
- Banks must assess risks in BAU (business as usual) as well as stressed environments
- Stress testing policies are an integral part of the risk governance framework:
  - Credit risk stress testing policy deals with factors impacting receivables
  - Market risk stress testing policy deals with stressed prices of traded securities, currencies, and interest rates
  - Liquidity risk stress testing policy deals with factors impacting the ability to make payments or finance growth
  - Operational risk stress testing policy deals with the failure of people, systems and processes

Stress testing approach

- The methodology for conventional banks, Islamic banks, and other financial institutions is the same



Stress testing uses *scenario analysis*

- Scenario analysis is a method banks use to measure the change in earnings, equity value, or liquidity when *multiple* risk factors change. Examples:
  - How much more will the bank earn if interest rates rise 10bps *and* inflation increases by 3% in the next 12-months?
  - What is the impact on net earnings if house prices fall 5% in the next 12-months *and* MYR strengthens 10% against USD?
- All of these examples concern changing more than one risk factor simultaneously, and measuring the corresponding change in earnings, value, or other performance measures
- The reasons for a change in risk factor are ignored, and so is its likelihood
- Importantly, the exposure amount is allowed to change as the risk factors change over time (unlike sensitivity analysis)

How to use stress testing: which risk factors matter?

- Is the bank exposed to the risk factor?
- Could a change in risk factor in a stress scenario cause a material change in net earnings, equity value or liquidity?
- Does the bank historically leave itself exposed to this risk factor or does the bank hedge this risk?
  - For example, commercial banks typically leave themselves exposed to interest rate risk so that margin income (NIM) expands when the economy grows
  - However, FX risk is usually routinely fully hedged and therefore matters less
- If we were to detect vulnerability to the risk factor in a stress scenario, would this mean the bank becomes unviable, e.g., breach of minimum regulatory capital requirement?
  - Clearly, any factor which potentially renders the ban unviable must be included

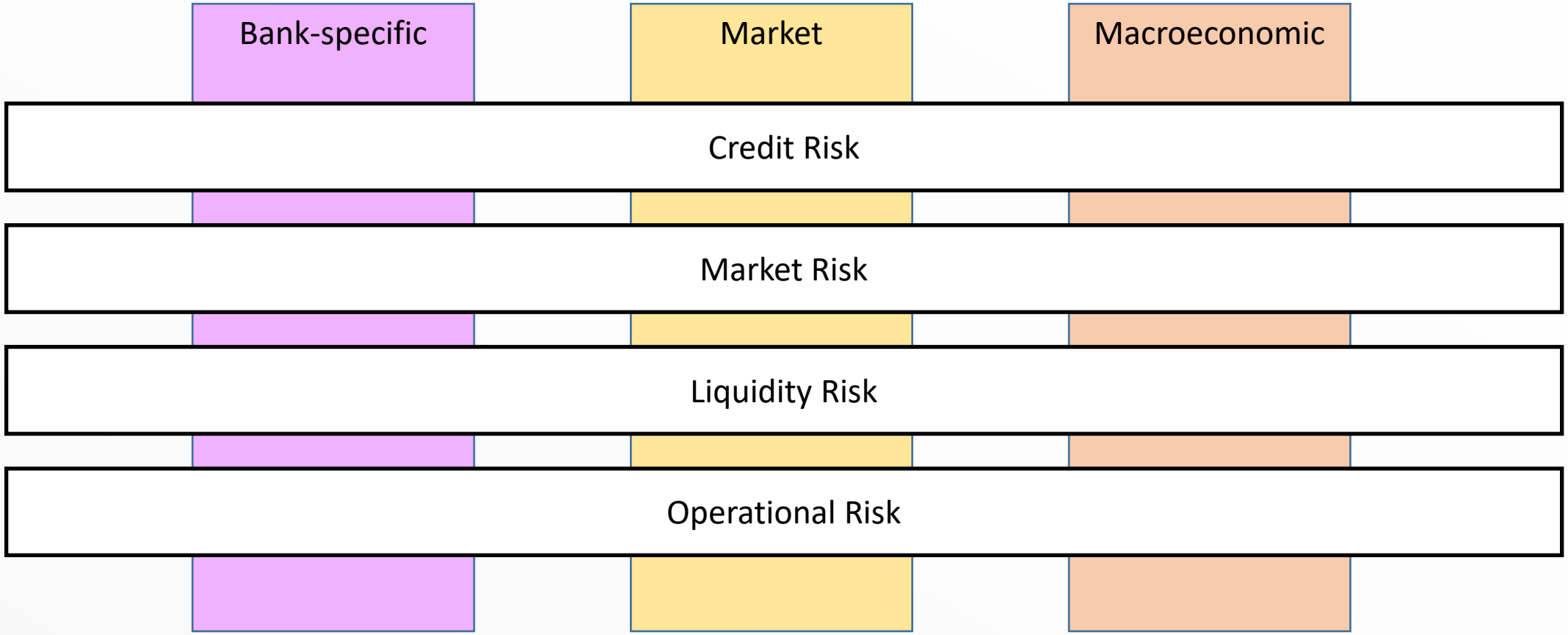
How do we integrate stress testing of credit, market and operational risk?

1. Identify the sources of risk. These are divided as follows:
   - Bank-specific factors, e.g., failure of ATMs, penalties for financial misconduct, core banking system offline etc.
   - Market factors, e.g., equity markets become distressed
   - Macro-economic, e.g., unemployment rises, house prices fall, interest rates rise
2. Determine the **combined potential impact** of all risk factors in the stress scenario
   - Credit risk, e.g., residential mortgages default whilst collateral values fall
   - Market risk, e.g., value of equity investments falls; new shares issued at lower price
   - Liquidity risk, e.g., ATM failure causes reputational damage, depositors withdraw funds unexpectedly, and the bank sources emergency funding at a higher cost
   - Operational risk, e.g., misconduct fines causing direct financial loss

Factors used in stress testing

Bank-specific risk factors	Market factors	Macroeconomic factors
Loan non-performance	Equity market prices	Inflation
Deposit withdrawals	Commodity market prices	Interest rates
New business growth	CDS spreads	FX rates
Asset impairment	Competition index	GDP growth
Project non-completion	Bond yields	Oil prices
Rollover risk on borrowings	Futures prices	Money supply
Leverage	Equity index volatility	Government debt
Concentration	Bond new issuance volumes	Unemployment

How do we integrate stress testing of credit, market and operational risk?



Integrated stress testing recognizes that each source of risk may impact more than one risk category

Quiz: Overview of Stress Testing

Which of the following is likely to create the most severe liquidity stress for a share margin financing business?*

A. A 5% fall in equity prices
B. A 5% rise in equity prices
C. A 10% fall in equity prices
D. A 10% rise in equity prices
E. None of the above

* i.e., the bank lends to buyers of shares, and uses the shares as collateral for the loan

Credit risk stress testing

What is this part about?

- Bank-level and macroeconomic factors impacting credit risk, e.g., credit moratoriums
- How to measure the impact of scenarios
- How to build informative stress scenarios
- How to calibrate normal versus stressed scenarios
- How to translate credit stress scenarios into resulting financial impact
  - Quantitative methods for stressed PD's and stressed Risk-Weights
  - The relevance and role of IFRS9 in stress testing
  - The role of collateral in measuring LGDs (loss given default)

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Bank-specific, market, and macroeconomic stress factors impacting Credit Risk

Bank-specific risk factors	Market factors	Macroeconomic factors
Loan non-performance	Interest rates	GDP growth
Single obligor concentration	CDS spreads	Inflation
Sectoral/industry concentration	Debt moratoriums	Money supply
Collateral impairment	Real estate prices	Government debt
Collections' systems failure	Raw materials input prices	Unemployment
Netting breakdown	FX rates	Civil unrest
Legal risk/Unenforceability	Equity prices	Political changes

How to measure the impact of scenarios

1. Create a baseline financial projection calibrated to a pre-defined set of risk factor values, e.g., forward interest rates, deposit growth, new business growth etc.
2. Calculate the resulting projected performance and risk metrics, e.g., net earnings, total assets, capital adequacy ratio etc.
3. Re-set the input assumptions for the scenario being evaluated
4. Recalculate the projected performance and risk metrics
5. Summarise the scenario impact as the difference in performance and risk metrics between the baseline results and scenario results

How to build informative scenarios

- Stress scenarios are used to identify vulnerabilities, not to predict the future
- As such, they must be based on realistic assumptions
  1. Risk factors must be relevant to the bank
  2. Changes in risk factors must be believable
  3. The relationship between risk factors generally reflects the norm. Examples:
     - equity market rallies are usually accompanied by a fall in bond prices
     - interest rate increases usually mean higher NPLs as obligors struggle to make promised interest and principal repayments
  4. There must be consistency within the scenario. Examples:
     - Higher NPLs from higher interest rates affects all sectors
     - Improved bank fundamentals usually results in lower funding spreads *unless* the scenario also includes a system-wide credit crunch
  5. Any change in exposure resulting from the scenario must be factored-in

How to build informative scenarios: Example of unemployment

- Suppose we want to know what unemployment rate to use in a stress scenario?
- The US unemployment rates are historically distributed as follows:

	Change in Unemployment rate over the horizon				
Time Horizon	> 1% Increase	> 2% Increase	> 3% Increase	> 4% Increase	> 5% Increase
1 year	19.5%	9.7%	5.3%	1.4%	1.2%
2 years	33.9%	20.5%	12.8%	5.0%	1.6%
3 years	44.1%	31.4%	19.5%	7.6%	3.1%
4 years	52.6%	40.0%	23.2%	10.4%	4.6%
5 years	59.1%	47.1%	27.9%	14.3%	4.8%

- Over 1-year, a rate increase of 3% or more happens 5.3% of the time
- Over 2-years, a rate increase of 4% or more happens 5.0% of the time
- Over 3-years, a rate increase of 5% or more happens 3.1% of the time

How to build informative scenarios: Example of unemployment

- Suppose the base case unemployment rate today is 2.0%, and this is projected to remain the same over the next 3-years
  - If a bad-case scenario is defined as occurring approx. 5% of the time, we use an increase in the unemployment rate of 3%, 4% and 5% over FY-1, FY-2, and FY-3
  - If a worst-case scenario is defined as occurring approx. 1% of the time, we would use an increase of 5% in FY-1, and possibly 6.5% in FY-2, and 8.0% in FY-3, noting that the highest unemployment rate in the US reached 10% during the GFC of 2007-9

Unemployment rate scenarios			
	FY-1	FY-2	FY-2
Base case	2.0%	2.0%	2.0%
Bad case	5.0%	6.0%	7.0%
Worst case	7.0%	8.5%	10.0%

How to build informative scenarios: Complexities

1. Cascading events
   - Scenarios are not for predicting future events but identifying vulnerabilities
   - However, in multi-period scenarios, one event can lead to another
     - e.g., higher NPL's leading to ratings downgrade leading to higher funding costs
   - Many-period scenarios become highly *subjective* because many more sequences of causally-related events are possible
2. Management actions
   - It is highly improbable that as events unfold, management would not take remedial actions
     - e.g., higher NPLs would lead to tighter lending conditions which eventually reduce further impairment losses

How to build informative scenarios: Complexities

- To deal with cascading events:
  1. Banks should rely on how events are related historically
  2. Banks should avoid too many cascades in a scenario
  3. Banks should prioritise short-term over long-term effects for decisions taken now
- To deal with management actions:
  1. Banks should evaluate scenarios *without* management actions *and with* (assumed) management actions in response to defined changes in operating conditions
  2. Banks should ensure that management have agreed their most likely response to well-defined changes in the future operating environment
     - most likely responses should be substantiated by past decisions wherever possible

How to calibrate normal versus stressed scenarios

Bank-specific risk factors	Market factors	Macroeconomic factors
Limit structures can be used to guide the calibration process. E.g., progressive worsening of liquidity outflows where liquidity coverage ratio falls to 0.90, then 0.80 etc. (stress) Debt covenants (externally imposed limits) are also useful E.g., interest coverage falls but does not breach covenants (normal)	Probability distributions e.g., normal changes are those within 2 standard deviations For distributions which are non-parametric (e.g., historical loss distributions), use the actual confidence level. e.g., normal losses are 99% of the distribution; stress losses are in the 1% tail	Conditional forecast of economic factors i.e., use of econometric analysis to determine the distribution of risk factors based on where we currently are in the economic cycle. For example, if at the top of the cycle (when assets are typically also overpriced), a drop in GDP is more likely than a further rise

How to translate scenarios into resulting financial impact

- Most stress testing starts with macroeconomic changes. For example:
  - GDP growth slows, becomes negative, and then slowly recovers
  - Unemployment levels climb rapidly
  - Inflation increases unexpectedly
  - House prices fall and mortgagees start defaulting in higher numbers
- The question is, what impact would these scenarios have on the bank? In other words, what is the *impact* of adverse scenarios on important measures such as
  - New loan growth
  - Net earnings
  - Loan non-performance
  - Liquidity
  - Capital adequacy

How to translate GDP scenarios into loan growth

- When economies contract, i.e., negative GDP growth, new loan growth also contracts
- To estimate the impact on new loan growth, banks typically use *interpolation* to translate GDP growth scenarios into loan growth*.
- Method:
  1. Identify
     - a high negative historic GDP growth rate and corresponding loan growth
     - the base case scenario GDP growth and corresponding loan growth
  2. Apply linear interpolation to calculate the loan growth corresponding to the scenario GDP growth rate

*Note: other factors can also be used in combination to determine loan growth, e.g., unemployment

How to translate GDP scenarios into loan growth

- Example
  - GDP growth rate in 1997 during the Asian financial crisis was approx. -7.0% p.a., with a corresponding loan growth rate of -2.5% p.a.
  - The base case GDP growth rate is 3.0% p.a. with loan growth rate 1.0% p.a.
  - Hence, if the GDP scenario growth rate is -2.0% p.a., then the scenario loan growth rate = 0.9% p.a. This is calculated from

$$3.0\% + \frac{(-2.0\% - 1.0\%)\big(3.0\% - (-2.5\%)\big)}{(-7.0\% - 1.0\%)}$$

How to translate credit risk scenarios into resulting financial impact

1: Regression analysis

- Measure the relationship between a set of macroeconomic factors and the bank's history of defaults
  - This needs to be done using defined portfolios of products and obligor types
  - The results of this analysis provides a way to project PDs based on projected macroeconomic factors, such as GDP, unemployment, inflation, etc.

2: Create a macroeconomic scenario i.e., a projection of GDP, inflation etc.

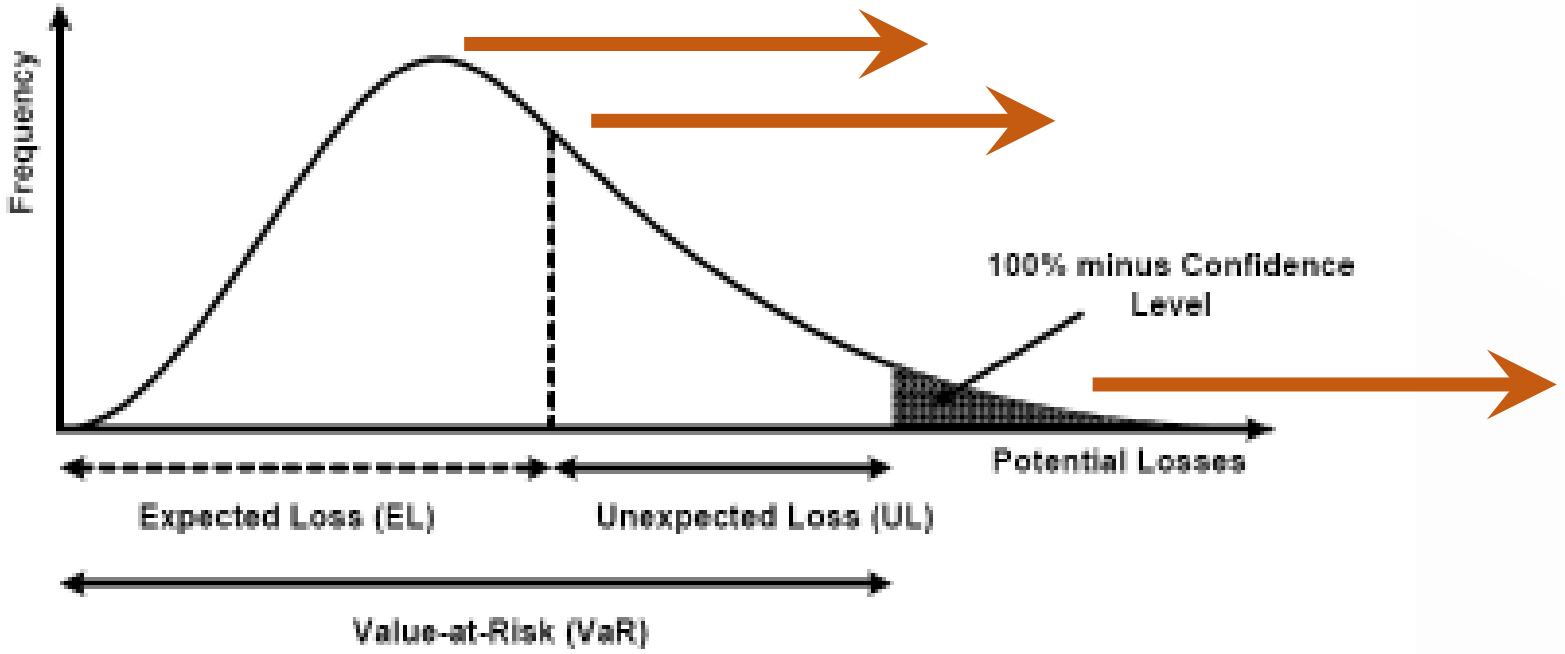
3: Calculate projected PDs corresponding to the future scenario

4: Calculate financial impact

- Translate the PDs to ECLs (expected credit losses) for provisioning requirements and loan write-offs to give the impact on net income.

Credit risk stress: Loan loss portfolio

The impact of stress is to stretch the distribution of losses to the right



Credit risk stress: Stressed PDs and Stressed risk-weights

- We need to translate the stretching of the loan loss distribution into financial impact
- To do this we use:
  - Stressed PDs (probabilities of default)
    - The expected credit loss, ECL = PD x LGD x EAD
    - Replacing BAU (business as usual) PDs with stressed PDs gives us stressed ECL
    - Stressed ECLs are used for provisions
    - Increases in provisions are charged to the income statement
  - Stressed risk-weights
    - The capital charge for risky loans = 8% x nominal exposure x risk-weight
    - We replace BAU risk-weights with stressed risk-weights
    - Using stressed risk-weights reduces capital adequacy

Credit risk stress: IFRS9 and staging

- The method for calculating provisions changed after the global financial crisis
- A far more forward-looking approach is now used to calculate expected losses
  - Previously, provisioning methods were based on incurred losses under IAS39
  - However, this method failed to provide an early warning of the failure of credit institutions
- IFRS9 uses 3-stages to indicate whether there has been a *Significant Increase in Credit Risk* (SICR) since initial recognition
  - Stage 1 – no significant increase in credit risk
  - Stage 2 – significant increase in credit risk – underperforming but not impaired
  - Stage 3 – significant increase in credit risk – non-performing, i.e., impaired
- Important!: SICR depends *only* on PD not LGD. So, even if collateral has deteriorated, if the PD has not changed, no SICR has occurred

Credit risk stress: IFRS9 and lifetime versus 12m PDs

- To determine SICR we need to calculate "lifetime PD"
- Consider 12m PDs for a 5-year loan originated in 2018

Period	Period	PD (unconditional)	Prob survival past end of FY	PD (conditional)
2018	FY-1	0.050	= 1 - 0.050 = 0.950	= 0.050
2019	FY-2	0.052	= 0.950 x (1– 0.052) = 0.9006	= 0.950 x 0.052 = 0.049
2020	FY-3	0.049	= 0.9006 x (1– 0.049) = 0.8565	= 0.9006 x 0.049 = 0.044
2021	FY-4	0.045	= 0.8565 x (1– 0.045) = 0.8179	= 0.8565 x 0.045 = 0.039
2022	FY-5	0.048	= 0.8179 x (1– 0.048) = 0.7787	= 0.8179 x 0.048 = 0.038

- The unconditional 12m PD shown for each year does not consider having survived previously, i.e., it is as if the loan has started in that year
- The PD we use in each year must be *conditioned* on surviving to that point in time
- The initial lifetime PD = 0.050 + 0.049 + 0.044 + 0.039 + 0.038 = 0.221

Credit risk stress: IFRS9 and SICR

- What is SICR?
  - IFRS9 does not provide a quantitative method to define SICR
  - Banks have flexibility to choose a method
  - However, what must be done is a relative comparison of 2-things:
    1. The lifetime PD for the projection horizon at initial recognition, with
    2. The lifetime PD for the projection horizon at the current reporting date
- Since not all banks have sophisticated credit risk models, simple rules can also be applied. For example, a loan becomes 90 days past-due so SICR has occurred, or if its internal credit score increases substantially.
- Qualitative rules can also be applied, e.g., a corporate obligor is expected to experience severe difficulty in servicing loan payments due to a downturn in demand for its product, and is moved from Stage-1 to Stage 2
- IFRS applies a “rebuttable presumption” that SICR occurs if a loan becomes 30 days past due unless a bank can prove otherwise

Credit risk stress: SICR rules

- Suppose we wish to determine whether SICR has occurred for a stress scenario

Period	Period	PD-Initial (UC)	PD-Initial (C)	PD-Stress (UC)	PD-Stress (C)
2018	FY-1	0.050	0.050	0.050	0.050
2019	FY-2	0.052	0.049	0.058	0.055
2020	FY-3	0.049	0.044	0.063	0.056
2021	FY-4	0.045	0.039	0.067	0.056
2022	FY-5	0.048	0.038	0.070	0.055

- For example, has a SICR occurred in 2020?
- The lifetime PD at initial recognition in 2020 = 0.044 + 0.039 + 0.038 = 0.122
- The lifetime PD for stress scenario in 2020 = 0.056 + 0.056 + 0.055 = 0.167
- This represents a 37% increase in lifetime PD. If the bank defines a SICR as a %age increase in lifetime PD of more than 20%, then a SICR has occurred

Credit risk stress: IFRS9

	Stage 1 Performing	Stage 2 Underperforming	Stage 3 Non-performing
PDs which apply	Next 12-months	Over the lifetime	Over the lifetime
Expected credit loss	Losses that result from default over the next 12-month	Losses that result from default over the remaining life	Losses that result from default over the remaining life
Interest revenue	Effective interest on carrying amount gross of accumulated provision	Effective interest on carrying amount gross of accumulated provision	Effective interest on carrying amount net of accumulated provision

Credit risk stress: how does this method charge the income statement?

Scenario impact possibilities	Impact on Income Statement
Stage-1 credit remains in Stage-1 but 12m ECL increases	Increase in ECL is charged to PNL
Stage-1 credit remains in Stage-1 but 12m ECL decreases	Decrease in ECL is released to PNL
Stage-1 credit moves to Stage-2 credit	Change from 12m ECL to lifetime ECL is charged to PNL
Stage-2 credit moves back to Stage-1 credit	Change from lifetime ECL to 12m ECL is released to PNL
Stage-2 credit remains in Stage-2 but lifetime ECL increases	Increase in ECL is charged to PNL
Stage-2 credit remains in Stage-2 but lifetime ECL decreases	Decrease in ECL is released to PNL
Stage-2 credit moves to Stage-3 credit Note: once impairment is realized, even if a restructured loan (net of write off amount) becomes performing, it is prudent to continue to apply Stage-3 rules to accrue interest and calculate provisions, i.e., Stage-3 is an “absorbing state”.	• The credit is no longer performing. • The provision is reversed and the LGD is charged to PNL. • If a Stage-3 credit is restructured, interest is thereafter accrued on a carrying amount *net* of the new accumulated provision.

Numerical example: Credit risk stress testing

- A bank provides a 10-year home loan with initial LTV 90% and a mortgage rate of 6%. The loan amortizes equally each year.
- Using historic analysis of defaults, the bank has identified 4 macroeconomic factors that are related to defaults:
  - GDP: gross domestic product, i.e., a measure of a country's economic output
  - Unemployment, i.e., the % of available workers who are unemployed
  - Interest rates: in particular, the Overnight Policy Rate (OPR)
  - House Price Index (HPI): the year-on-year %age change in house prices
- Using an econometric regression, the bank derives the following equation:

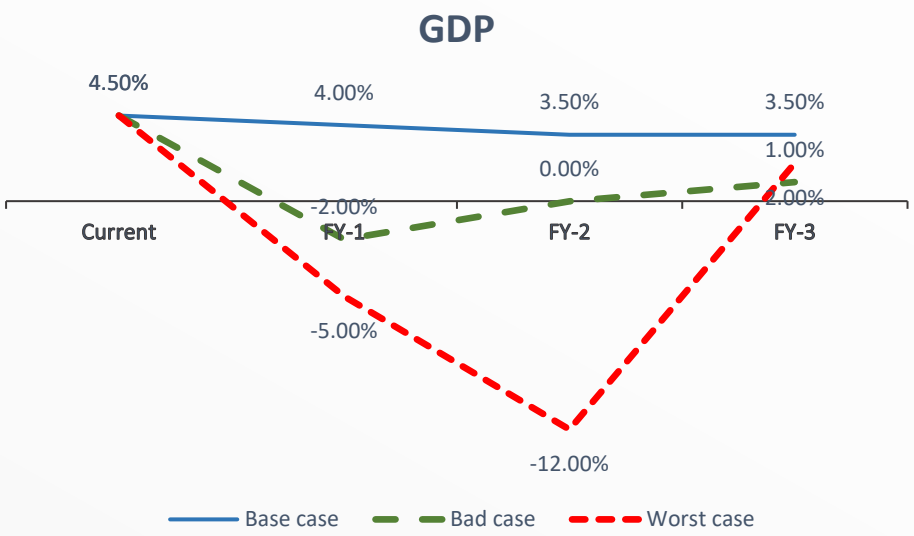
$$12m\ PD = 0.03 - 0.90GDP + 0.70UNEMP + 0.40INT - 0.015HPI$$

Numerical example: Credit risk stress testing

- The bank runs three scenarios: base case; bad case; worst case

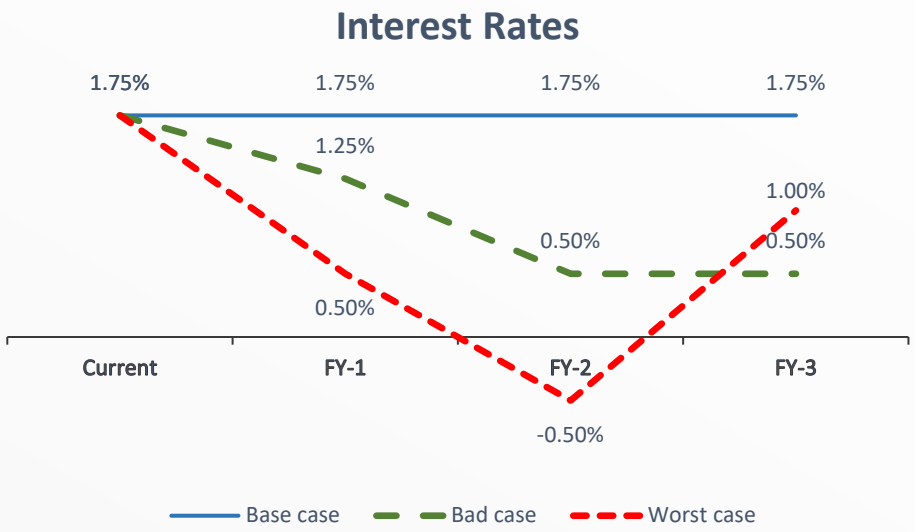
Scenario	Factor	FY-1	FY-2	FY-3
Base case	GDP	4.00%	3.50%	3.50%
	UNEMP	5.10%	5.40%	5.60%
	INT	1.75%	1.75%	1.75%
	HPI	0.80%	0.90%	1.10%
Bad case	GDP	-2.00%	0.00%	1.00%
	UNEMP	5.50%	7.00%	6.00%
	INT	1.25%	0.50%	0.50%
	HPI	-15.00%	-6.00%	2.00%
Worst case	GDP	-5.00%	-12.00%	2.00%
	UNEMP	6.50%	8.00%	7.00%
	INT	0.50%	-0.50%	1.00%
	HPI	-25.00%	-15.00%	20.00%

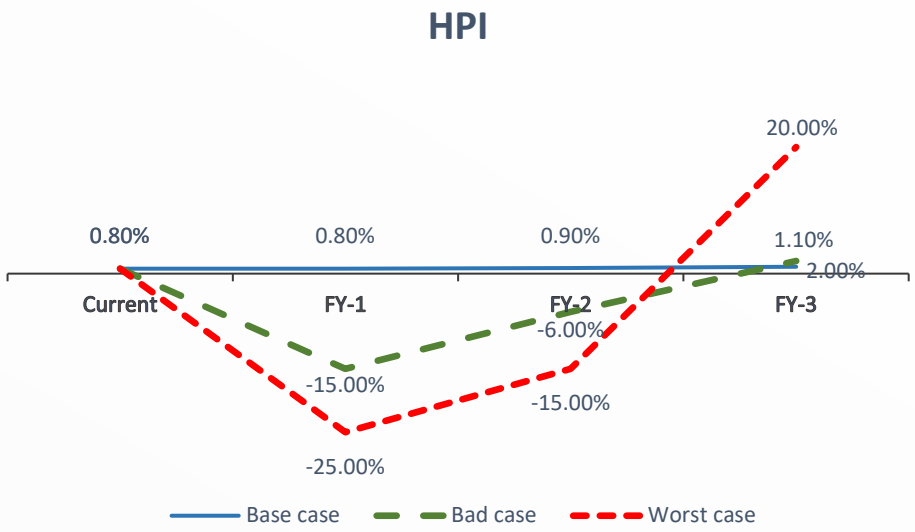
Numerical example: Credit risk stress testing



- Bad case: contraction in growth with protracted recovery; unemployment rising gradually
- Worst case: very severe contraction but economy rebounds quickly from low-point; unemployment rises gradually and reaches higher rate than bad case

Numerical example: Credit risk stress testing





- Bad case: interest rates fall as government tries to stimulate the economy; house prices fall and recover slowly
- Worst case: interest rates fall faster than in bad case but rise faster once economy rebounds; house prices fall and recover quickly from low-point

Numerical example: Credit risk stress testing

Definition of SICR

- The bank defines a Stage-1 credit being one for which the %age change in lifetime PD is less than 20% relative to lifetime PD at initial recognition
- The bank defines a Stage-2 credit being one for which the %age change in lifetime PD is equal to or more than 20%, but less than 40%, relative to lifetime PD at initial recognition
- The bank defines a Stage-3 credit as one for which the %age change in lifetime PD is equal to, or more than 40% relative to lifetime PD at initial recognition. If a credit becomes Stage-3 and is restructured, then it remains in Stage-3 until maturity.

Requirement

Calculate the ECLs for the loan for FY-1, FY-2 and FY-3 in each scenario

Numerical example: Credit risk stress testing

1. Calculate the unconditional and conditional 12m PDs in each projection year
2. Calculate the lifetime PDs in each projection year from that point in time to maturity of the loan
   - assume that unconditional PDs from FY-4 onwards equal FY-3 values
   - Lifetime PDs are the sum of 12m conditional PDs in the projection period
3. Compare the %age change in lifetime PDs in each year in each scenario to the lifetime PDs at initial recognition, i.e., relative to its value in the base case scenario
4. Determine which stage the credit is in for each year to the projection horizon
   - this establishes whether a 12m ECL or a lifetime ECL applies
5. Calculate the LGD in each year in each scenario using the outstanding loan amount and the value of the collateral in the scenario
   - HPI and haircuts (to market value) determine the value of the collateral
6. Calculate the ECLs as discounted value of 12m PD(cond.) x LGD aggregated over each remaining year to maturity of the loan

Numerical example: Credit risk stress testing

- Using the econometric equation for the unconditional PDs, the 12m PDs are:

	FY-1	FY-2	FY-3
12m PD (Unconditional)			
Base	0.0366	0.0432	0.0445
Bad	0.0938	0.0819	0.0647
Worst	0.1263	0.1943	0.0620
12m PD (Conditional)			
Base	0.0366	0.0416	0.0411
Bad	0.0938	0.0742	0.0538
Worst	0.1263	0.1697	0.0436

Numerical example: Credit risk stress testing

- The lifetime PDs, %age change since initial recognition, and stage decisions are:

Lifetime PD at start of FY	FY-1	FY-2	FY-3
Base	0.3450	0.3084	0.2668
Bad	0.4748	0.3810	0.3068
Worst	0.5823	0.4561	0.2864
%age change since initial recognition			
Base	0%	0%	0%
Bad	38%	24%	15%
Worst	69%	48%	7%
SICR decision			
Base	Stage-1	Stage-1	Stage-1
Bad	Stage-2	Stage-2	Stage-1
Worst	Stage-3	Stage-3	Stage-3

Numerical example: Credit risk stress testing

- The outstanding loan amount, collateral value, LGDs and ECLs are:

	FY-1	FY-2	FY-3
Outstanding loan	50,000	45,000	40,000
Collateral value			
Base	33,600	20,341	12,339
Bad	25,500	14,382	8,802
Worst	25,000	12,750	9,180
LGDs			
Base	16,400	29,659	37,661
Bad	24,500	30,618	31,198
Worst	25,000	32,250	30,820
ECLs			
Base	566	1,164	1,459
Bad	9,042	7,288	1,584
Charged to PNL for Stage-3 credits			
Worst	25,000	-	-

Collateral value is the product of YOY changes in HPI and the recovery rate

LGD equals:
- Zero if collateral value > O/s loan, or
- O/s loan minus collateral value otherwise

ECLs equal:
- 12m PD * LGD for 12m ECLs
- Discounted sum of PD (conditional) in each year * LGD in each year to maturity for lifetime ECLs

Numerical example: Credit risk stress testing

- Other points to note:
  - The lifetime ECL is calculated as

$$\sum_{i=1}^{N} \frac{12m\ PD_i(cond.) * LGD_i}{(1+r)^i}$$

  - The summation is over the remaining N-years to maturity using the conditional 12m PD in each year
  - The discount rate (r) is the EIR (effective interest rate) of the loan
    - Since loans are issued at par, this is the interest (profit) rate on the loan

Numerical example: Credit risk stress testing

- Stress testing also means that risk-weights are stressed
  - Stressed risk weights mean higher capital charges
- For credit stress, we use the *Vasicek Loan Loss Distribution* to derive stressed RW from stressed PD. The method is as follows:
  1. Knowing the base case PD, we can use the base case risk weight to derive the model parameter, ρ
  2. Then, using our calculated value for ρ, we calculate the stressed VaR (value at risk)
  3. Lastly, stressed RW = (stressed VaR – stressed PD)/8%

Numerical example: Credit risk stress testing

- Using our example of a 5-year retail loan (which has a BAU RW of 75%):
  - VaR loss = (8% x 75%) + 0.037 (base case 12m PD) = 0.097
  - The ρ value for a VaR loss of 0.097 at 99.99% confidence and PD of 0.037 is 0.0183
  - For FY-1 in the bad case, applying a ρ of 0.0183 and stressed PD of 0.094 at 99.99% confidence gives a stressed VAR loss of 0.206
  - Hence, the stressed FY-1 RW in the bad case = (stressed VaR – stressed PD)/8%, i.e. (0.206 – 0.094)/0.08 = 140%

Numerical example: Credit risk stress testing

- Applying the same method, we derive the following stressed RWs for the retail loan in each FY

Retail risk-weights	FY-1	FY-2	FY-3
Base case	75%	75%	75%
Bad case	140%	110%	90%
Worst case	165%	180%	80%

- When projecting the net income for each of the stress scenarios using the stressed ECLs, we have to also calculate the corresponding Capital Adequacy Ratios (CARs) using the stressed RWs for each FY

Quiz: Measuring the Impact of Credit Stress

Which of the following is true for stage 2, as defined in IFRS9?

A. ECL is based on a 12-month view; effective interest is on gross carrying amount
B. ECL is based on a 12-month view; effective interest is on net carrying amount
C. ECL is based on a lifetime view; effective interest is on gross carrying amount
D. ECL is based on a lifetime view; effective interest is on net carrying amount
E. All of the above

*Note: gross means without deducting provisions; net means after deducting provisions

Appendix: Vasicek Loan Loss Distribution

$$Pr.(L < \theta) = N\left(\frac{\sqrt{1-\rho}N^{-1}(\theta) - N^{-1}(12m\ PD)}{\sqrt{\rho}}\right)$$

- The formula gives the probability of a loan loss L less than θ %
- Parameter ρ has to be calculated using the base case risk weight
- $N(x)$ is the cumulative normal probability, i.e. the probability that a random drawing from normal distribution with zero mean and unit variance has a value less than x

Other stress testing approaches

What is this part about?

- Reverse stress testing
- Spillover effects and how to assess contagion risk
- Tips for effective stress-test reporting

Reverse stress testing

- Reverse stress testing starts with bank failure and then traces back to the combination of operating conditions that would lead to that outcome, e.g., market events, political events
- The output of reverse stress testing is a scenario or number of scenarios that lead to failure. These are then compared to the bank's version of an "extreme" scenario
- If the two are not comparable, then the bank's stress-testing framework is altered accordingly

Reverse stress testing

- To apply reverse stress testing, we have to define the point of non-viability (PONV, i.e. failure). The following is an example using regulatory ratios:

Capital adequacy ratios	Liquidity ratios
CET1 < 4.5% + 0.5%	LCR < 1.01
Tier-1 < 6.0% + 0.5%	NSFR < 1.01
Total Capital Ratio < 8.0% + 0.5%	

- Other examples include severe ratings downgrades or even events leading to the suspension of banking license (e.g., violation of AML requirements)

Reverse stress testing

- Typically, RSTs are applied to a 12-month horizon
- For capital non-viability:
  - Since 3 sets of capital ratios can be used (i.e., CET1, Tier-1, and TCR), the PONV is the smallest loss required until the first one of these is breached.
  - Then the question is: could the group or its entities reasonably lose that amount of capital in a bank-specific or market stress?
- For liquidity non-viability:
  - the RST result could be expressed in terms of how many of the largest fund providers would need to withdraw funding before the LCR or NSFR point of non-viability is reached.
- Translating RST results into easily-understood measures is very useful

Spill-over and how to assess contagion

- This is a very interesting but challenging area of risk management
- Banks are exposed to the risk that market-wide risks (i.e., systemic risk) may adversely impact counterpart financial institutions (FI's)
- Banks are directly exposed to the risk of failure of other FI's in a number of ways. There are many examples:
  - Interbank lending (risk of default) and borrowing (risk of non-rollover) is probably the most important direct linkage between banks
  - Joint investment in shared projects/ventures, e.g., a partner fails to make stage payments
  - Derivative transactions (usually collateralised)
  - Syndications, e.g., the counterpart bank is lead arranger in a term-funding arrangement
- Banks are also indirectly exposed to all other banks through common risk factors, e.g., market confidence leading to bank runs

Spill-over and how to assess contagion

- There are a large number of spillover channels to the real economy.
- Example of risk transmission and linkages:
  - Banks reduce lending because the regulator imposes a higher capital adequacy requirement
  - Obligors relying on refinancing their existing obligations cannot make repayments, causing a widespread increase in delinquencies
  - Savers withdraw deposits in fear of losing capital (even when insured by the government), worsening the liquidity crisis faced by banks and further reducing lending to the real economy

Spill-over and how to assess contagion

- The risk of contagion of a bank relies on its *interconnectedness* with other banks, and in particular to smaller banks. Why?
  - Smaller banks are less likely to receive government bail-outs
  - Larger banks are considered “too big to fail”, so more likely to receive government funding in the event of emergencies
  - It is clearly better to diversify connectivity with other banks, particularly where other banks are a funding source
- Given that connectivity to a particular bank is both direct and indirect (through other banks), probability models of risk based on network theory are used. However, these are highly complex.
- Therefore, simple risk capture using exposure levels is sufficient as a first step to assess contagion risk

Spill-over and how to assess contagion

- One approach is to assess where the bank is located in the the financial sector topography, i.e., picture of connections between banks
- Both the number and type of connections need to be assessed, even if the resulting assessment seems rudimentary. Even simply counting the number of banks with a material connection is a start.
- Criteria include:
  1. Is the connection domestic or foreign?
  2. How many connections are there to each other bank?
  3. How large is the connection, and is it material to the bank?
  4. Is the connection time-bound (i.e., temporary, as in interbank lending) or permanent (e.g., to a group entity or in a joint venture with another bank)

Quiz: Other Stress Testing Approaches

Which of the following is true of reverse stress testing (RST)?

A. RST measures the impact of a pre-defined scenario
B. RST measures the impact of a random scenario
C. RST identifies which events could lead to failure only due to insolvency
D. RST identifies which events could lead to failure, however the bank defines it
E. None of the above

Thank You