AFIN8003 Week 7 - Credit Risk II: Loan Portfolio and Concentration Risk

Banking and Financial Intermediation

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1 Credit Risk II: Loan Portfolio and Concentration Risk

1.1 Why this week matters

! The last time Australian banks nearly failed

Between 1990 and 1992 Australian banks lost more than **A$9 billion** before tax, over a third of the entire system's shareholders' funds in 1989. Non-performing loans peaked at about **6%** of all lending.
Hardly any of it was one bad borrower. It was **one sector**: commercial property. When Westpac finally revalued its property assets, they were worth about **40% less**.
Every state-owned bank in Australia was closed or broken up.[1]

- Every one of those loans was approved by someone who had done the Week 6 analysis properly.
- The loans were fine one at a time. The **portfolio** was a single bet.
- **Portfolio risk is not the sum of loan risks.**

i It still happens

March 2024: **New York Community Bancorp** took a $1 billion rescue investment after losses on its commercial property book. Same sector, same mistake, thirty years later.

1.2 Roadmap: one question, asked three ways

In Week 6 you priced **one** loan. This week the bank holds thousands of them, and they do not fail independently.

Everything today answers a single question: **how much of this risk can the bank actually get rid of?**

	The question	What we build
1	Can we *see* the concentration?	Migration analysis, concentration limits
2	Can we *diversify* it away?	MPT for loans, Moody's RiskFrontier
3	Can we *sell* it?	Credit forwards, options and swaps

The answer, given away in advance

Question 2 has an uncomfortable answer: **only partly**. There is a floor below which diversification cannot take you, however many loans you add.
That floor is the reason question 3 exists.

[1] Figures from Gizycki and Lowe (2000). The State Bank of Victoria and the State Bank of South Australia each lost more than three times their 1989 shareholders' funds.

2 Question 1: can we see the concentration?

2.1 Simple models

Caution

A large credit risk exposure to a single borrower, or to a group of borrowers exposed to the **same risk factor**, poses a potential threat to a bank's safety and soundness.

Which side of the balance sheet?

Concentration can bite on either side. SVB in Week 4 was concentrated in its **depositors**. This week is about concentration in the **loan book**.

- Regulations limit such exposure, so individual loans rarely cause bank failures outright.
- The real danger: pools of loans that **look different but share the same risk driver** behave identically in a downturn.
- Think of the 2008 GFC. Mortgages, CDOs, structured credit, MBS, and derivatives were marketed as *different products* but were all bets on U.S. house prices. When the one underlying factor turned, everything turned.

The hidden-correlation trap

Products with different names, sold by different business units, can still share the same underlying risk. A bank's "diversified" book may be one bet in disguise.

Two simple models widely used to measure concentration risk:

1. Migration analysis
2. Concentration limits

2.2 Simple model: migration analysis

- Track credit ratings of certain types of loans or certain sectors, either externally from credit rating agencies or internally.
- If actual rating deteriorates faster than historical experience, limit lending to that loan class or sector.
- Historical credit migration measured through **loan migration matrix** (or transition matrix).

Table 2: Example loan migration matrix

	AAA-A	BBB-B	CCC-C	Default
AAA-A	0.85	0.10	0.04	0.01
BBB-B	0.12	0.83	0.03	0.02
CCC-C	0.03	0.13	0.80	0.04

Table 2, for example, shows the *transition probabilities* of loans that began the year with a certain credit rating being upgraded/downgraded to a certain rating, or default.

- The probability of AAA-rated loan at the start of a year being downgraded to BBB to B by the year's end is 0.10.
- The probability of AAA-rated loan at the start of a year being downgraded to CCC to C by the year's end is 0.04.
- The probability of AAA-rated loan at the start of a year defaults by the year's end is 0.01.

2.3 Simple model: migration analysis (cont'd)

In practice, FIs use migration matrices with many more rating classes (S&P uses 20+).

Migration analysis is also applied to credit card and consumer loan portfolios.

> ⚠ Where migration analysis can mislead you
>
> - **Historical data only.** This is "last war" risk.[2] Matrices built on 2010s data missed COVID-era dislocations.
> - **Rating agencies lag.** Downgrades typically arrive *after* trouble is visible. By the time ratings downgrade, the market has already repriced.
> - **Point-in-time vs through-the-cycle.** The same rating can mean different things across agencies and time.

> ℹ Discussion
>
> Lehman Brothers was rated A by S&P five days before its September 2008 bankruptcy. What does that tell you about relying on migration analysis alone?

2.4 Simple model: concentration limits

- Caps the maximum loan size to an individual borrower, sector, or geographic area.
- Used to reduce exposure to some industries and increase it in others.
- Aggregate limits applied to industries whose performance is highly correlated.
- **Regulatory floors:**
  - **US (OCC):** loans to a single borrower capped at 15% of bank's capital (25% if fully secured).
  - **Australia (APRA APS 221):** large exposures to a single counterparty (or group) generally capped at 25% of Tier 1 capital; a tighter 15% limit applies to a D-SIB's exposure to another systemically important bank.

$$\text{Concentration limit} = \text{Maximum loss as a percentage of capital} \times \frac{1}{\text{Loss rate}}$$

> ℹ Example
>
> A manager unwilling to lose more than 15% of capital, facing an estimated loss rate of 40% in an industry, sets the limit at $15\% \times \frac{1}{0.4} = 37.5\%$ of the loan portfolio.

2.5 Simple model: concentration limits (cont'd)

Let's look at a real Australian bank. Notice anything?

Table 3: BOQ credit exposures by industry, 31 August 2025. Source: BOQ APRA Basel III Pillar 3 disclosures

Sector	$m	% of total
Residential mortgages	53,351	74.0
Property and construction	6,904	9.6
Other	3,485	4.8
Healthcare	2,657	3.7

[2] Incorrectly use strategies from a previous crisis to solve a completely new one.

Sector	$m	% of total
Professional services	1,854	2.6
Agriculture	1,466	2.0
Transportation	853	1.2
Manufacturing and mining	785	1.1
Hospitality and accommodation	658	0.9
Other retail lending	131	0.2
Total	**72,144**	**100.0**

Discussion

74% in residential mortgages. Is BOQ diversified across ten sectors, or is it one bet on Australian house prices wearing ten different hats? This pattern is typical of Australian banks, and it is one reason APRA stress-tests them on a property downturn.

3 Question 2: can we diversify it away?

3.1 Modern Portfolio Theory, in plain English

The one idea

The risk of a portfolio is **not** the average of the risks of the things inside it. It is almost always lower, because the pieces do not all move at the same time.

Markowitz (1952) turned that observation into a procedure:

1. For every possible mix of assets, compute two numbers: expected return R_p and risk σ_p.
2. Plot every mix as one point.
3. Discard any mix where some other mix gives **more return at the same risk**, or **the same return at less risk**.
4. What survives is the **efficient frontier**.

Why a bank should care

An FI does not choose loans one at a time, it chooses a *mix*. Two loan books can earn the identical spread and carry very different risk, purely because of who the borrowers are.

What it asks you for

Three numbers per asset: expected return, risk, and how it co-moves with everything else. The third does most of the work, and for loans it is by far the hardest to obtain.

3.2 Loan portfolio diversification and MPT

MPT can be used to measure and control an FI's aggregate credit risk exposure.

Any model that seeks to estimate an efficient frontier for loans needs to determine and measure three things:

- The expected return on individual loans
- The risk of individual loans
- The correlation of default risks between loans

Expected return R_p of a portfolio of N assets:

$$R_p = \sum_{i=1}^{N} X_i R_i$$

where

- R_i is the expected return on the ith asset
- X_i is the proportion of the asset portfolio invested in the ith asset (the desired concentration amount)

3.3 Loan portfolio diversification and MPT (cont'd)

Variance of returns (or risk) of the portfolio σ_p^2 can be calculated as

$$\begin{aligned}\sigma_p^2 &= \sum_{i=1}^{N} X_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{\substack{j=1 \\ j \neq i}}^{N} X_i X_j \sigma_{ij} \\ &= \sum_{i=1}^{N} X_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{\substack{j=1 \\ j \neq i}}^{N} X_i X_j \rho_{ij} \sigma_i \sigma_j\end{aligned}$$

where

- ρ_{ij} is the correlation between the returns on the ith and jth assets
- σ_i^2 is the variance of returns on the ith asset
- σ_{ij} is the covariance of returns between the ith asset and jth asset

3.4 An illustration

3.5 The efficient frontier, and choosing one point on it

Interactive in the online slides: sliders for the correlation between two assets and the risk-free rate, drawing the frontier, the minimum-variance portfolio, and the portfolio with the highest Sharpe ratio.

The frontier says which mixes are *worth considering*. To pick **one**, rank them by return earned per unit of risk, the **Sharpe ratio** (Sharpe 1966):

$$S = \frac{R_p - r_f}{\sigma_p}$$

The best one is where a line from r_f just touches the frontier.

> **ℹ Three things to try**
>
> 1. **Drag ρ to $+1$.** The frontier straightens into a line and the grey inefficient arm disappears. At perfect correlation there is nothing to diversify.
> 2. **Drag ρ to -1.** The frontier bows out until risk almost vanishes at the minimum-variance point. Same two assets, same returns, far less risk.
> 3. **Raise r_f.** The tangency point slides along the frontier: a higher risk-free rate makes you demand more from the risky mix.

> **! Now put loans in it**
>
> Nothing above is specific to shares. R_i and σ_i can also represent the expected return and risk of loans, so that the same picture prices a **loan portfolio**. That is exactly what RiskFrontier does

next.

3.6 How much risk can diversification remove?

Interactive in the online slides: sliders for the average correlation between loans and the risk of a single loan, tracing portfolio risk as the number of loans grows.

! The floor

Add as many loans as you like. Portfolio risk cannot fall below

$$\sigma_{\text{floor}} = \sigma\sqrt{\rho}$$

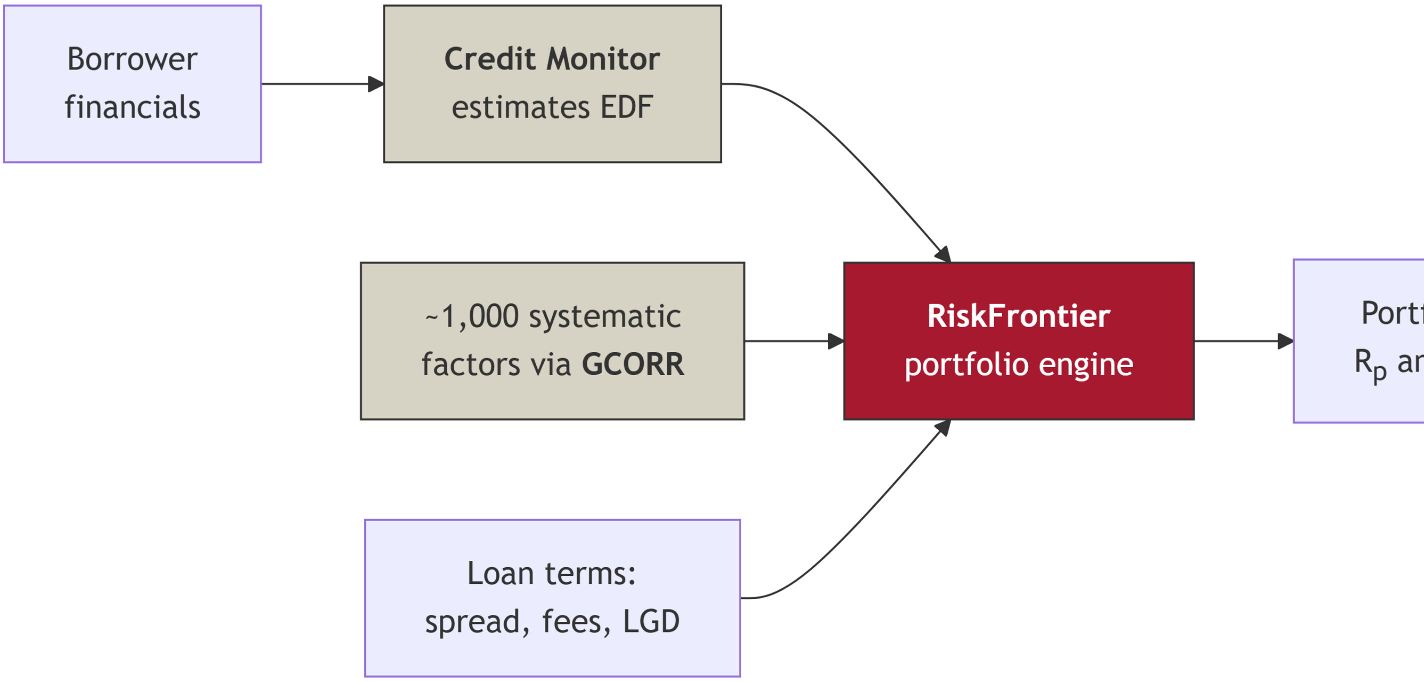
At $\rho = 0$ the floor is zero and diversification removes everything. At $\rho = 0.2$ it is 0.45σ, no matter how many loans you hold.

i Why this is the most important slide of the week

Everything a bank can do about the **downward-sloping part** of that curve is diversification. Everything it can do about the **flat part** is either hold capital against it or sell it to somebody else. Correlation is what makes the floor high. A book of 200 Australian mortgages is 200 loans and roughly one bet.

3.7 Moody's RiskFrontier: the big picture

The problem: MPT needs **three inputs**, and for a loan portfolio none of them are directly observable.



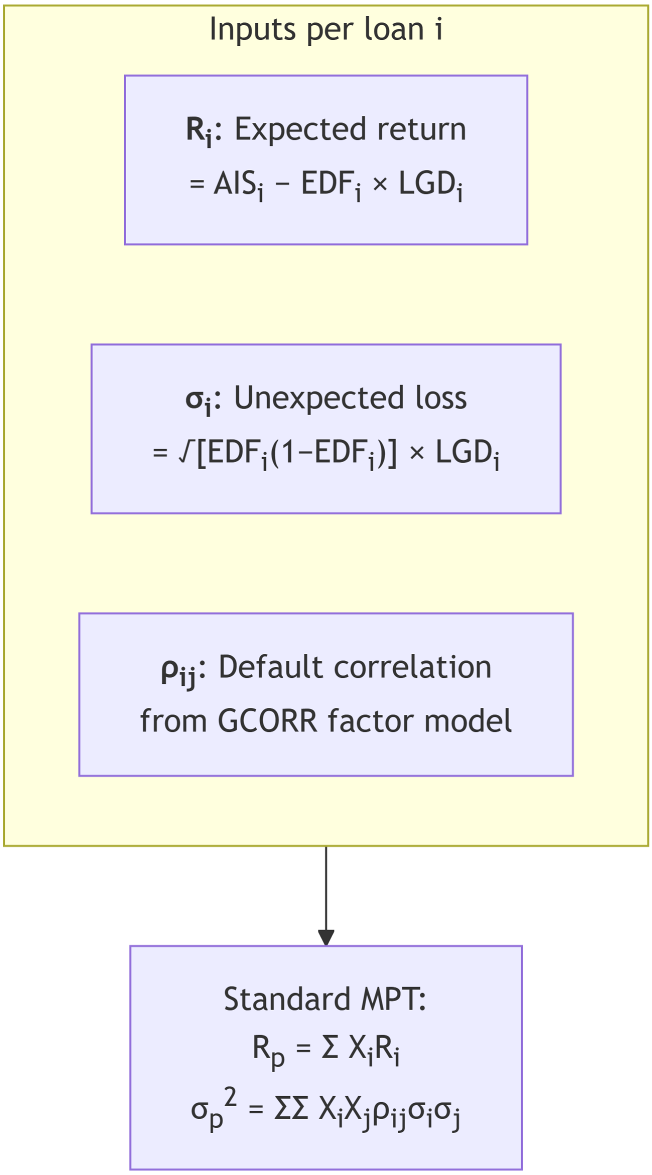
Two Moody's models in sequence:

1. **Credit Monitor** → produces EDF (Expected Default Frequency) for each borrower
2. **RiskFrontier** → plugs EDFs, LGDs, and correlations into MPT to get portfolio R and

> 💡 Why not just use historical correlations?
>
> Most loans never trade, so there is no price series to correlate. RiskFrontier instead computes correlations from **shared exposure to systematic factors**: GCorr distinguishes 61 countries and 49 industries, and runs to close to 1,000 factors in total.

3.8 RiskFrontier: the three MPT inputs

The whole model is just **three numbers per loan**, fed into standard MPT formulas.



Symbol	Meaning	Source
AIS	All-in-drawn spread (loan rate − cost of funds + fees)	Loan contract
EDF	Prob. of default in the next year	Credit Monitor

Symbol	Meaning	Source
LGD	Fraction lost if default occurs	Basel floors or bank estimate[3]
	Default correlation	GCORR factor model

3.9 RiskFrontier: expected return and risk

Expected return: earn the spread, lose the expected loss.[4]

$$\underbrace{R_i}_{\text{net return}} = \underbrace{AIS_i}_{\text{spread + fees}} - \underbrace{EDF_i \times LGD_i}_{E(L_i),\text{ expected loss}}$$

Unexpected loss: default is binomial, so has a closed form.[5]

$$\sigma_i = UL_i = \underbrace{\sqrt{EDF_i(1 - EDF_i)}}_{\sigma \text{ of a 0/1 default event}} \times \underbrace{LGD_i}_{\text{loss if default}}$$

Intuition

- **Expected loss** (EDF × LGD) is already *priced into* the spread. It is the cost of doing business.
- **Unexpected loss** ( ) is what you hold capital against. It is the surprise.

3.10 RiskFrontier: where correlations come from (GCORR)

Default correlations between two loans cannot be directly observed. GCORR computes them via a **factor model**: two borrowers are correlated to the extent they share exposure to the *same underlying risk factors*.

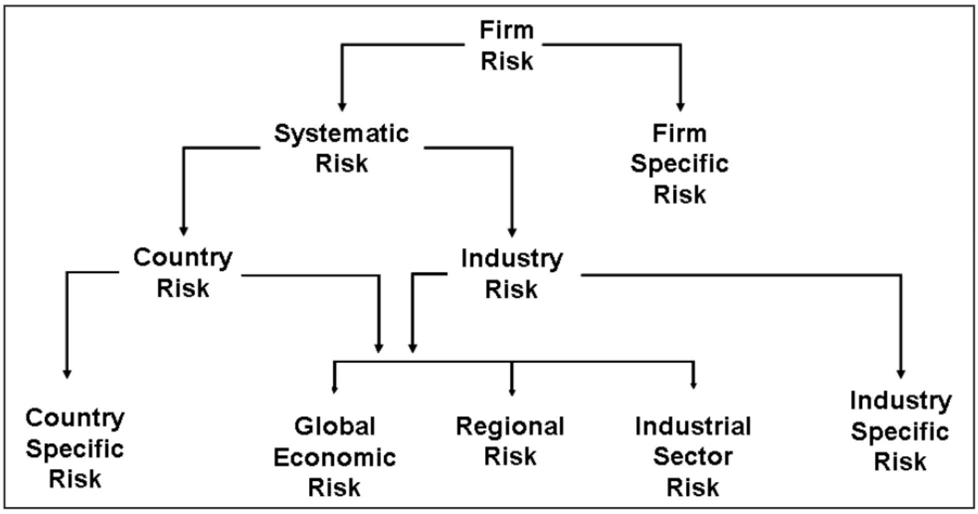


Figure 1: Moody's GCorr Corporate factor structure

[3] Basel Foundation IRB (CRE32): senior unsecured exposures to corporates = **40%** (45% for banks and other financial institutions), subordinated = **75%**; lower LGDs apply to collateralised exposures (e.g., 20% for receivables or CRE/RRE collateral, 25% for other physical collateral).

[4] In Saunders et al. (2023), this equation has a typo: $E(L_i)$ is written as $R(L_i)$.

[5] In Saunders et al. (2023), this equation is incorrectly written.

Read Figure 1 this way

Each borrower's asset return = **global economy** + **region/country** + **industry** + **firm-specific noise**. Two borrowers are correlated only through the **shared** branches of the tree. A Sydney miner and a Perth miner share the "Australia + Materials" branches, so is high. A Sydney miner and a Berlin software firm share almost nothing, so is near zero.

3.11 Moody's Analytics RiskFrontier Model (example)

Suppose that an FI holds two loans with the following characteristics. Assume that the correlation $\rho_{12} = -0.25$, what are the return and risk of the portfolio?

Loan i	X_i	Spread between loan rate and FI's cost of funds	Fees	LGD	EDF
1	0.6	5%	2%	25%	3%
2	0.4	4.5%	1.5%	20%	2%

The return and risk on loan 1 are:

$$R_1 = (0.05 + 0.02) - (0.03 \times 0.25) = 0.0625$$
$$\sigma_1 = \sqrt{0.03 \times 0.97} \times 0.25 = 0.04265$$

The return and risk on loan 2 are:

$$R_2 = (0.045 + 0.015) - (0.02 \times 0.2) = 0.056$$
$$\sigma_2 = \sqrt{0.02 \times 0.98} \times 0.2 = 0.028$$

The return and risk of the portfolio are then:

$$R_p = 0.6 \times 0.0625 + 0.4 \times 0.056 = 0.0599 \text{ or } 5.99\%$$
$$\sigma_p^2 = (0.6)^2(0.04265)^2 + (0.4)^2(0.028)^2 + 2(0.6)(0.4)(-0.25)(0.04265)(0.028) = 0.0006369$$
$$\sigma_p = \sqrt{0.0006369} = 0.0252 = 2.52\%$$

3.12 Regulatory models

- **Fed's 1994 Ruling on Credit Concentration Risk**
  - Subjective approach based on examiner discretion.
  - Rejected technical models: data and methods were too undeveloped at the time.
- **2006 regulatory tightening**
  - **BIS:** 10 principles on credit risk assessment and supervisory evaluation.
  - **OCC:** guidance on sound risk management for commercial real estate (CRE) lending.
- **OCC/Fed Joint Study (April 2013).** The numbers are striking:

Bank profile during GFC	Failure rate
Construction loans > 100% of capital	**13%**
Exceeded BOTH construction AND total CRE criteria	**23%**
Did not exceed either criterion	0.5%

> **Takeaway**
>
> Banks that breached both concentration criteria failed at **46 times** the rate of banks that breached neither. Concentration guidance is advisory. The statistical case for it is not.

4 Question 3: can we sell it?

4.1 Credit derivatives

- Diversification is the first line of defence. Derivatives are the second.
- The key insight: **credit derivatives separate the credit risk from the lending relationship**. A bank can keep the client, service the loan, and still offload the default risk to someone else.
- Three main instruments: credit **forwards**, credit **options**, credit **swaps** (including CDS).

> **Why this innovation matters**
>
> Before credit derivatives (pre-1990s), the only way a bank could reduce credit exposure to a big client was to **refuse the loan** or **sell it**, both of which damage the relationship. Credit derivatives let the bank say "yes" and still cap its downside.

4.2 Credit forward contracts and credit risk hedging

- A credit forward is a forward agreement that hedges against an increase in default risk of a firm (borrower).[6]
- Specifies a credit spread on a benchmark bond issued by the borrower.
- Used to **hedge against credit deterioration** (spread widening)
- Spread is measured vs. a risk-free Treasury
- Example: BBB bond trades at 2% spread over Treasury

4.3 Credit forward contracts and credit risk hedging (cont'd)

Market outcome	Long position (hedger)	Short position
Spread widens → credit quality worsens	Gains (receives payment)	Loses (makes payment)
Spread tightens → credit quality improves	Loses (makes payment)	Gains (receives payment)

- If $\phi_T > \phi_F$: Long receives $(\phi_T - \phi_F) \times MD \times A$
- If $\phi_T < \phi_F$: Long pays $(\phi_F - \phi_T) \times MD \times A$

where

- ϕ_F is the credit spread on which the credit forward contract is written
- ϕ_T is the actual credit spread on the bond when the credit forward matures
- MD is the modified duration on the benchmark bond
- A is the principal amount of the forward agreement

[6] See A Note on Credit Spread Forwards for some discussion on the potential confusion due to different definitions.

- **Long position** protects against borrower credit quality getting worse
- **Short position** benefits if borrower credit improves
- Acts like a **put-style hedge** for lenders

4.4 Credit options

Credit options are a small corner of the market. Credit default swaps make up the large majority of US bank credit-derivative notional (78% in the first quarter of 2026), with total return swaps and credit options sharing the remainder.

- A **credit spread call option** is a call option whose payoff increases as the (default) risk premium or yield spread on a specified benchmark bond of the borrower increases above some exercise spread.
- A **digital default option** is an option that pays a stated amount in the event of a loan default (the extreme case of increased credit risk).

4.5 Credit (default) swaps (CDS)

The most important, and most controversial, credit derivative.

Explosive growth, then regulatory pushback:

Table 8: US commercial bank credit-derivative notional. Source: OCC Quarterly Report on Bank Trading and Derivatives Activities

Date	US bank credit-derivative notional	Note
2000	\$0.43 trillion	Market in its infancy
March 2008	\$16.44 trillion	Pre-GFC peak
September 2011	\$15.66 trillion	Still near the peak
September 2021	\$3.9 trillion	Post-Dodd-Frank trough
March 2026	**\$6.7 trillion**	CDS \$5.2tn, 78% of the total

! Down 75%, then back up

Dodd-Frank (2010) pushed standardised CDS onto **central clearinghouses**, with margin requirements that made speculative positions far more expensive. Bilateral dealer books shrank by roughly three quarters from the 2008 peak.
Note the last row. The market has been **growing again** since. Central clearing did not kill CDS, it changed who bears the counterparty risk.

Why CDS exist:

1. Credit risk is still the leading cause of FI failure, ahead of interest-rate or FX risk.
2. CDS let FIs keep **long-term customer relationships** while offloading default risk.

4.6 Basics of CDS

- **CDS Payments**: The buyer makes periodic payments to the seller (quarterly, semi-annually, or annually) until the end of the swap or a credit event (e.g., default) occurs.
- **Settlement**: Upon default, settlement involves either physical delivery of bonds (loans) or a cash payment.

  - The protection buyer receives a payment upon the occurrence of a credit event trigger, but the swap "expires worthless" if no trigger occurs.
- No requirement that the CDS buyer actually owns the underlying reference securities.
- The CDS buyer hedges its exposure to default risk, but there is still counterparty credit risk in the event that the seller fails to perform their obligations under the terms of the contract.[7]

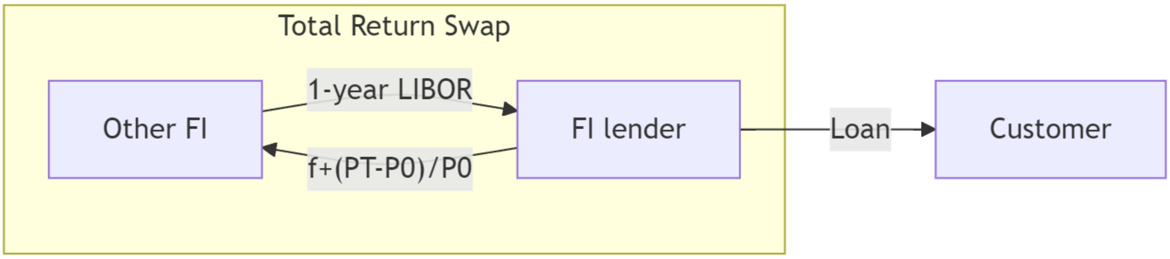
We examine two types of credit swaps:

1. total return swap
2. pure credit swap

4.7 Credit swaps: total return swaps

A **total return swap** involves *swapping* an obligation to pay interest at a specified fixed or floating rate *for* payments representing the total return on a loan or a bond (interest and principal value changes) of a specified amount.

The figure below illustrates a total return swap.[8]



The FI lender pays a fixed annual rate f plus changes in the market value of the loan and receives a variable rate payment (historically **1-year LIBOR**; post-2023 **SOFR** in USD, **AONIA/BBSW** in AUD since LIBOR's cessation in June 2023).

- Interest rate risk remains. The TRS transfers credit *and* market risk of the asset, but the fixed vs floating mismatch is still an interest-rate exposure.

[7] **AIG** had written hundreds of billions of dollars of CDS protection, much of it on subprime mortgage exposures, without posting collateral against it. When spreads widened in 2008 it faced margin calls it could not meet, and the US government committed up to **$182 billion** in rescue financing. The lesson: protection is only as good as the counterparty who sold it. This is why **central clearing** is now standard for CDS.

[8] In the textbook Saunders et al. (2023), Figure 25-4 incorrectly has $f - \frac{P_t - P_0}{P_0}$.

4.8 Credit swaps: total return swaps (cont'd)

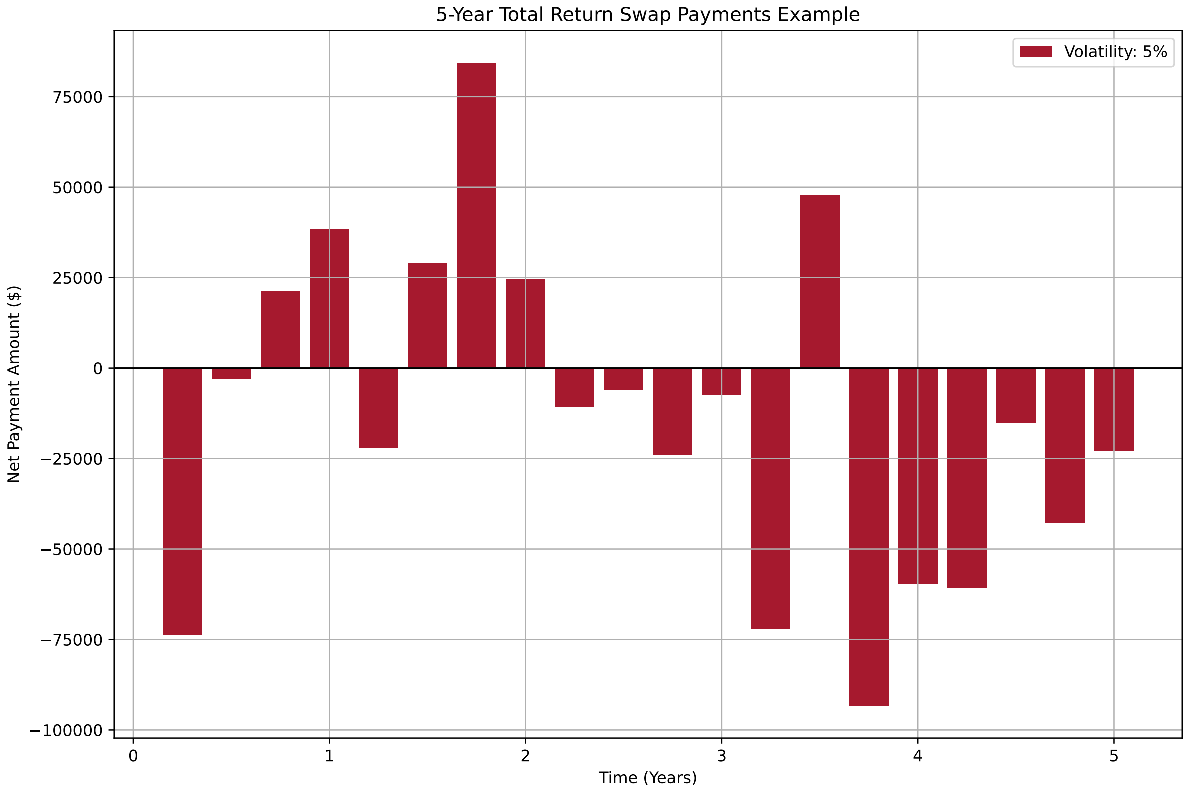


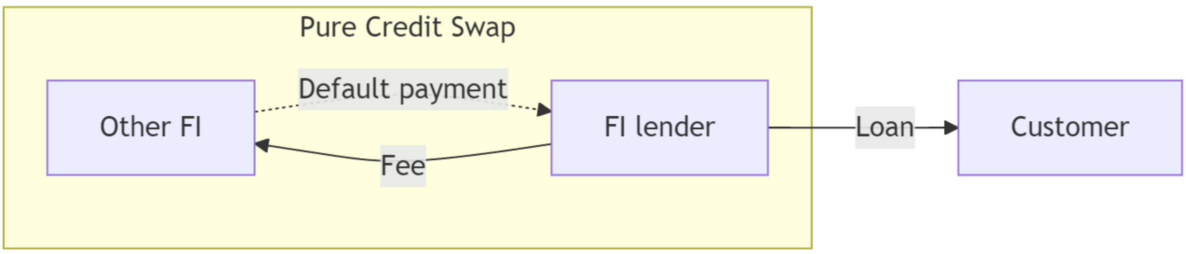
Figure 2: Total Return Swap Payments Example

4.9 Credit swaps: pure credit swaps

Interest-rate sensitive element stripped out leaving only the credit risk.

Similar to buying an insurance:

- If default, the counterparty makes the default payment
- If not default, the FI receives nothing from the counterparty.



4.10 Credit swaps: pure credit swaps (cont'd)

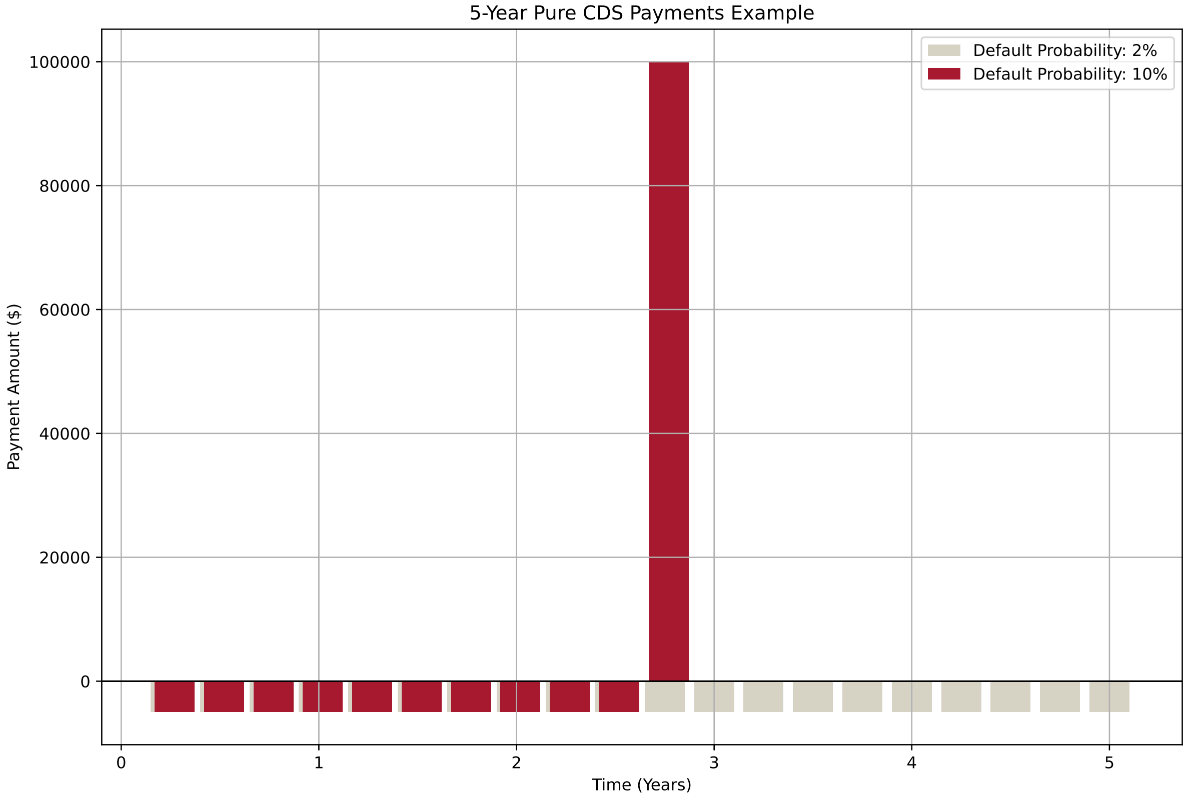


Figure 3: Pure CDS Payments Example

5 Finally...

5.1 Key takeaways

1. **Concentration, not individual default, is the usual killer.** Loans that "look different" often share one risk factor.
2. **Migration analysis** is useful but backward-looking. Rating agencies lag reality.
3. **MPT applies to loans**, with adaptations (RiskFrontier): expected loss = EDF × LGD, risk = √(EDF(1-EDF)) × LGD, correlations come from factor models (GCORR), not history.
4. **Derivatives separate credit risk from the lending relationship.** TRS transfers total return; pure CDS transfers only default risk.
5. **Counterparty risk is real.** AIG 2008 is the cautionary tale. Central clearing is the post-GFC response.

5.2 Suggested readings

- Moody's Analytics: An Overview of Modelling Credit Portfolios
- BIS CRE32: IRB approach and risk components (for the LGD floors)
- OCC Quarterly Report on Bank Trading and Derivatives Activities (for current credit-derivative notionals)

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