Managing Credit Risk

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Learning outcome

- Discuss types and characteristics of loans made by banks
- Explain the return on loans
- Demonstration different methods for estimating the credit risk exposure
- Understand the credit risk in a loan portfolio context

Credit Quality Problems

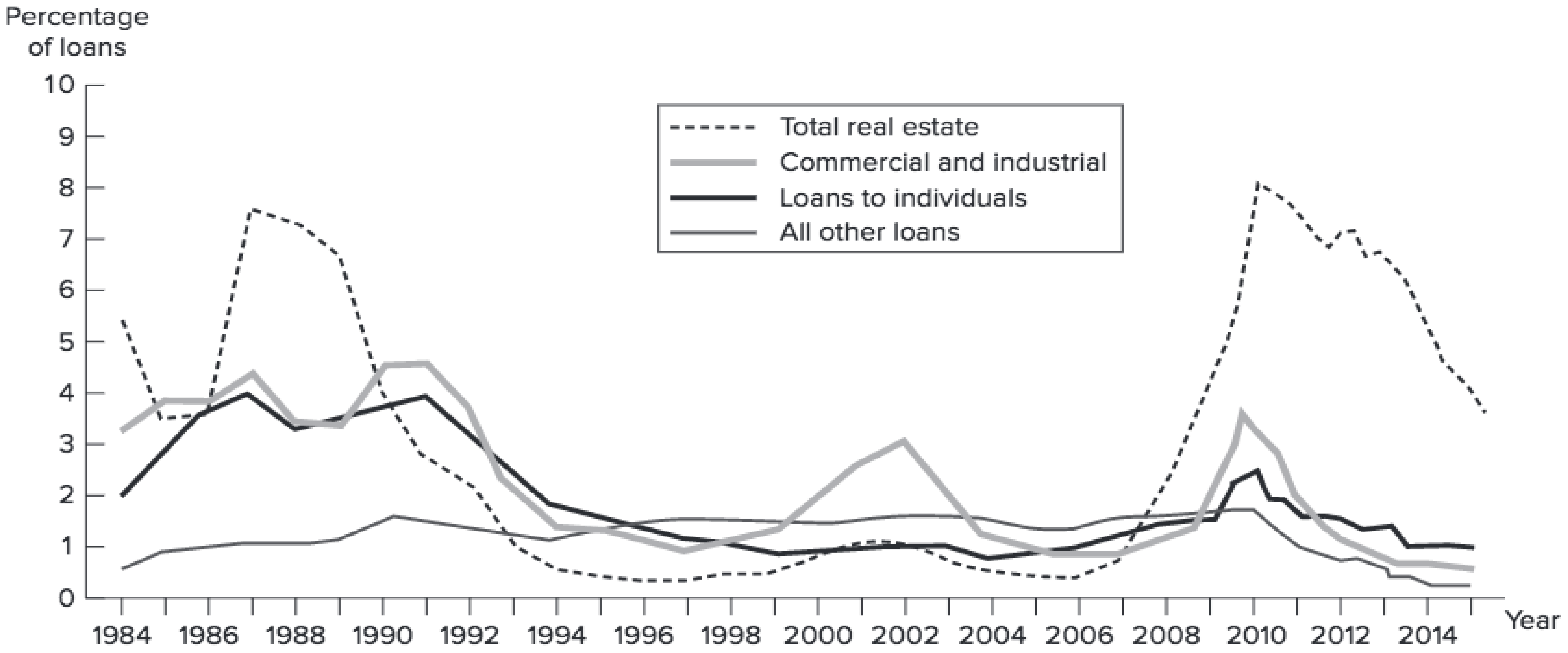
Problems with junk bonds, loans, and residential and farm mortgage loans.

Examples:

1. Late 1990s, credit card and auto loans
2. Crises in other countries such as Argentina, Brazil, Russia, and South Korea
3. 2006-2007, mortgage delinquencies on subprime loans surged

Emphasizes importance credit risk analysis

Nonperforming Asset Ratio for U.S. Commercial Banks



Fundamental Credit Issues

There are two types of errors in judgment when evaluating loan requests:

1. The first is extending credit to a customer who will ultimately default.
2. The second is denying a loan to a customer who would ultimately repay the debt.

Bankers tend to focus on eliminating the first type of error but turning down goods loans is also unprofitable.

Types of Loans

C&I loans: secured and unsecured

- Syndication
- Spot loans, loan commitments
- Decline in C&I loans originated by commercial banks and growth in commercial paper market
- Effect of financial crisis on commercial paper market

RE loans: Primarily mortgages

- Fixed-rate, ARMs
- Mortgages can be subject to default risk when loan-to-value rises and house prices fall below amount of loan outstanding

Types of Loans (Cont.)

Consumer loans: personal, auto, credit card

- Nonrevolving loans
  - Automobile, mobile home, personal loans
- Revolving loans
  - Credit card debt (i.e., Visa, MasterCard)
  - Proprietary cards, such as Sears and AT&T
- Risks affected by competitive conditions and usury ceilings
- Bankruptcy Reform Act of 2005

High default rates during finance crisis highlight the importance of risk evaluation prior to making a credit decision

Types of Loans (Cont.)

Other loans include:

- Farm loans
- Other banks
- Nonbank FIs, such as broker margin loans
- Foreign banks and sovereign governments
- State and local governments

Calculating Return on a Loan

Factors: Interest rate, fees, credit risk premium, collateral, and other non-price terms, such as compensating balances and reserve requirements

$$1 + k = 1 + (of + (BR + \emptyset))/(1 - [b(1 - RR)])$$

Where:

k is the promised gross return

of = direct fees (origination fees)

BR + ø = loan interest rate

b= Compensating balance

RR = Reserve Rate

Example

Confidence Bank has made a loan to Risky Corporation. The loan terms include a default risk-free borrowing rate of 8 percent, a risk premium of 3 percent, an origination fee of 0.1875 percent, and a 9 percent compensating balance requirement. Required reserves at the Fed are 6 percent. What is the expected or promised gross return on the loan?

$$1 + k = 1 + \frac{of + (BR + \varphi)}{1 - [b(1 - RR)]}$$

$$1 + k = 1 + \frac{0.001875 + (0.08 + 0.03)}{1 - [0.09(1 - 0.06)]} = 1 + \frac{0.111875}{0.9154} = 1.1222 \ \ or\ k = \ 0.1222$$

Credit Decisions

At retail

- Usually a simple accept/reject decision rather than adjustments to the rate
- Credit rationing
- If accepted, customers sorted by loan quantity
- For mortgages, discrimination occurs via loan-to-value rather than adjusting rates

At wholesale

- Use both quantity and pricing adjustments

Risk Models

Availability, quality, and cost of information are critical factors in credit risk assessment

- Facilitated by technology and information

Qualitative models consider borrower specific factors as well as market, or systematic, factors

- Borrowed-specific factors include reputation, leverage, volatility of earnings, and collateral
- Market specific factors include business cycle and interest rate levels

Linear Probability Model

Credit scoring models are quantitative models that use borrower characteristics to gauge an applicant's probability of default

$$PD_i = \sum_{j=1}^{n} \beta_j X_{i,j} + error$$

- Major weakness is that estimated probabilities of default can often lie outside of the [0,1] interval
- Since superior statistical techniques are readily available, there is rarely justification for employing linear probability models

Logit Model

Logit models

- Overcomes weakness of the linear probability model by restricting the estimated range of default probabilities from the linear regression model to lie between 0 and 1

Quality of credit scoring models have improved, providing positive impact on controlling write-offs and default

Altman’s Discriminant Function

$$Z=1.2X_1+ 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5$$

- X_1 = Working capital/total assets ratio
- X_2 = Retained earnings/total assets ratio
- X_3 = EBIT/total assets ratio
- X_4 = Market value equity/ book value of total liabilities
- X_5 = Sales/total assets ratio

A score below 1.81 means likelihood of bankruptcy and greater than 2.99 is safe.

Example

Suppose that the financial ratios of a potential borrowing firm take the following values:

Working capital/total assets ratio (X1) = 0.75

Retained earnings/total assets ratio (X2) = 0.10

Earnings before interest and taxes/total assets ratio (X3) = 0.05

Market value of equity/book value of total liabilities ratio (X4) = 0.10

Sales/total assets ratio (X5) = 0.65

Calculate the Altman's Z score for the borrower in question. How is this number a sign of the borrower's default risk?

$Z = 1.2(0.75) + 1.4(0.10) + 3.3(0.05) + 0.6(0.10) + 1.0(0.65) = 0.90 + 0.14 + 0.165 + 0.06 + 0.65 = 1.915 <$ than 3, decline the loan request.

Altman’s Discriminant Function (Cont.)

Problems associated with discriminant analysis model:

- Only considers two extreme cases (default/no default)
- No reason to expect that the weights in a credit scoring model will be constant long-term; sensitivity to variable weights
- Ignores hard to quantify factors, including business cycle effects and reputation
- Database of defaulted loans is not available to benchmark the model

Term Structure Derivation of Credit Risk

If the risk premium is known, we can infer the probability of default

Risk premium can be computed using Treasury strips and zero-coupon corporate bonds

$$p(1+k) = 1+i$$

Where:

p=the possibility of default

k= promised gross return

i= the treasury strip rate

Example:

If the rate on one-year Treasury strips currently is 6 percent, what is the repayment probability for the one-year AA-rated zero coupon bond yielding 9.5 percent?

Probability of repayment = p = (1 + i)/(1 + k)

For an AA-rated bond = (1 + 0.06)/ (1 + 0.095) = 0.9680, or 96.80 percent

=> probability of default = 1 – 0.9680 = 0.0320, or 3.20%

Mortality Rate Models

- Similar to the process employed by insurance companies to price policies; the probability of default is estimated from past data on defaults

- Marginal Mortality Rates:

$$\boldsymbol{MMR_1} = \frac{(Value\ grade\ B\ Default\ in\ Yr\ 1)}{(Value\ Grade\ B\ outstanding\ yr\ 1)}$$

$$\boldsymbol{MMR_2} = \frac{(Value\ grade\ B\ Default\ in\ Yr\ 2)}{(Value\ Grade\ B\ outstanding\ yr\ 2)}$$

$$\boldsymbol{Cumulative\ survival\ rate} = \prod_{i=1}^{n} (1 - MMR_i)$$

Has many of the problems associated with credit scoring models, such as sensitivity to the period chosen to calculate the MMRs

Example:

The following is a schedule of historical defaults experienced by an bank.

	Year 1	Year 2	Year 3	Year 4	Year5
Annual default	0.00%	0.10%	0.50%	0.20%	0.30%

What are the probabilities that each type of loan will not be in default after five years?

The cumulative survival rate is = $(1 - MMR_1) \times (1 - MMR_2) \times (1 - MMR_3) \times (1 - MMR_4) \times (1 - MMR_5)$

$(1 - 0.00) \times (1 - 0.001) \times (1 - 0.005) \times (1 - 0.002) \times (1 - 0.003) = 0.989$ or 98.9%.

RAROC Models

Risk-adjusted return on capital

- One of the most widely used models

  - *RAROC = (One year NI on a loan)/(loan risk)*

Loan risk estimated from loan default rates, or using duration

Using Duration to Estimate Loan Risk

For denominator of RAROC, duration approach used to estimate loss in value of the loan:

$$\frac{\Delta LN}{LN} = -D_{LN} \times \left(\frac{\Delta R}{1+R}\right)$$

Where:

ΔLN = changes in loan value

LN = Loan value

$-D_{LN}$ = Loan Duration

ΔR = change in the spread in yields between Treasury bonds and corporate bonds

R = yields of the corporate bonds

Example

A bank wants to evaluate the credit risk of a $5 million loan with a duration of 4.3 years to a AAA borrower. There are currently 500 publicly traded bonds in that class (i.e., bonds issued by firms with a AAA rating). The current average level of rates (*R*) on AAA bonds is 8 percent. The largest increase in credit risk premiums on AAA loans, the 99 percent worst-case scenario, over the last year was equal to 1.2 percent (i.e., only 6 bonds out of 500 had risk premium increases exceeding the 99 percent worst case). The projected (one-year) spread on the loan is 0.3 percent and the FI charges 0.25 percent of the face value of the loan in fees. Calculate the capital at risk and the RAROC on this loan.

The estimate of loan (or capital) risk is:

$\Delta LN = -D_{LN} \times LN \times (\Delta R/(1 + R)) = -4.3 \times \$5m \times (0.012/(1 + 0.08)) = \$238,889$

Spread = 0.003 x $5 million = $15,000

Fees = 0.0025 x $5 million = $12,500 $15,000 + $12,500 = $27,500

The loan’s RAROC is: RAROC = $27,500/238,889 = 11.51%

Option Models

Employ option pricing methods to evaluate the option to default

Used by many of the largest banks to monitor credit risk

Merton showed market value of a risk loan:

$L(\tau) = Be^{-i\tau}[\left(\frac{1}{d}\right) N(h_1) + N(h_2)]$

$d = L/A$

$h_1 = -[{}^{\sigma^2}/_2 \times \tau - \ln(d)]/(\sigma\sqrt{\tau})$

$h_2 = -[{}^{\sigma^2}/_2 \times \tau + \ln(d)]/(\sigma\sqrt{\tau})$

Where:

$L(\tau)$ = the market value of loan

B = the face value of the loan

τ = remaining time to maturity

e = the natural logarithm

d = borrower’s leverage ratio

σ = standard deviation of the underlying assets

N = standard normal distribution probability

Option Models (cont.)

Written as a yield spread:

$$k_\tau - i = ({}^{-1}/_{\tau})\ln[N(h_2) + \left(\frac{1}{d}\right)N(h_1)]$$

Where:

k_τ=required yield on risky debt

i = risk-free rate on debt of equivalent maturity

τ = remaining time to maturity

Example

Calculate the value of and interest rate on a loan using the option model and the following information.

Face value of loan (B) = \$500,000

Length of time remaining to loan maturity (τ) = 4 years

Risk-free rate (i) = 4%

Borrower's leverage ratio (d) = 51%

Standard deviation of the rate of change in the value of the underlying assets = 15%

Example (Cont.)

Substituting these values into the equations for h_1 and h_2 and solving for the areas under the standardized normal distribution, we find that:

$$h_1 = -\frac{[0.5 \times 0.15^2 \times 4 - ln(0.51)]}{0.15 \times \sqrt{4}} = -2.39448$$

$$h_2 = -\frac{[0.5 \times 0.15^2 \times 4 + ln(0.51)]}{0.15 \times \sqrt{4}} = 2.09448$$

$$L(\tau) = Be^{-i\tau}[\left(\frac{1}{d}\right) N(h_1) + N(h_2)]$$

= \$500,000 *e*-0.04(4) [*N*(-2.39448) x 1.6667 + *N*(2.09448)]

= \$426,071.89[0.008332 x 1.6667 + 0.981846] = \$424,254

$$k_\tau - i = \left({}^{-1}/{}_{\tau}\right)\ln[N(h_2) + \left(\frac{1}{d}\right) N(h_1)]$$

= (-1/4)ln[0.981846 + 0.008332 x 1.6667] = 0.001069 = 0.1069%

Thus, the risky loan rate *k*(τ) should be set at 4.1069 percent when the risk-free rate (*i*) is 4 percent.

Simple Models of Loan Concentration

- Migration analysis
  - Track credit ratings of firms in a particular sector or ratings class for unusual declines
  - **Loan migration matrix** reflects historic credit rating experience of a pool of loans and serves as a measure of the probability of the loan being upgraded, downgraded, or defaulting over some specified period
- Widely applied to commercial loans, credit card portfolios, and consumer loans

Loan Migration Matrix

	Risk rating: end of year 1	Risk rating: end of year 2	Risk rating: end of year 3	Risk rating: end of year D*
Risk rating: beginning of year: 1	.85	.10	.04	.01
Risk rating: beginning of year: 2	.12	.83	.03	.02
Risk rating: beginning of year: 3	.03	.03	.80	.04

Simple Models of Loan Concentration (Cont.)

Management sets external limit on maximum amount of loans to be made to individual borrower or sector (i.e., **concentration limits**)

- CL = (max loss as % of capital)(1/loss rate)
- Used by banks to limit exposure between highly correlated industries and geographic locales

Example

A manager decides not to lend to any firm in sectors that generate losses in excess of 5 percent of capital.

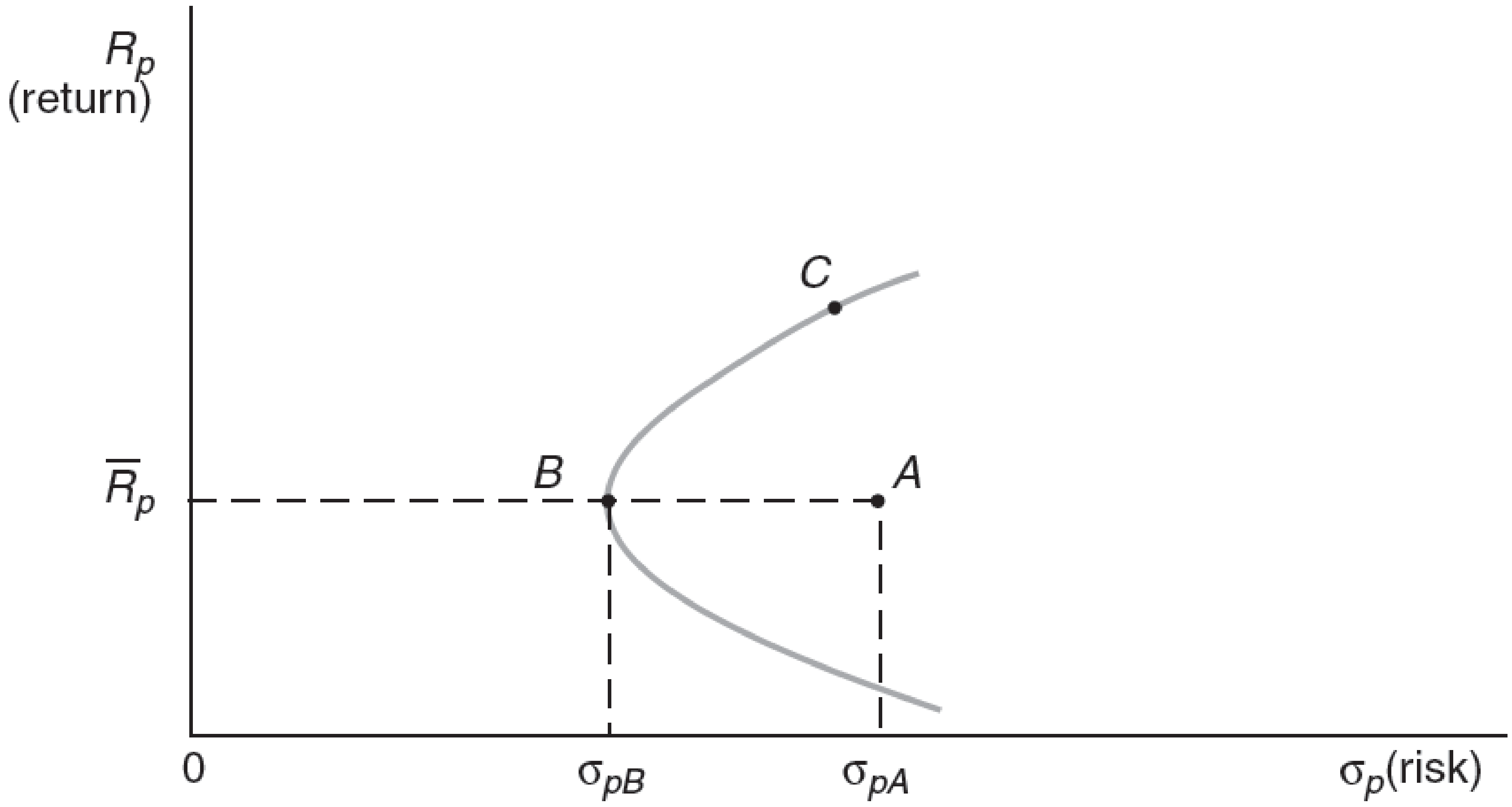
If the average historical losses in the automobile sector total 8 percent, what is the maximum loan a manager can lend to firms in this sector as a percentage of total capital?

Concentration limit = (Maximum loss as a percent of capital) x (1/Loss rate) = 0.05 x 1/0.08 = 62.5 percent of capital is the maximum amount that can be lent to firms in the automobile sector.

Modern Portfolio Theory (MPT)

- Using MPT allows banks to diversify sizeable amounts of credit risk exposure by taking advantage of its size
  - Returns of assets within the portfolio must be imperfectly correlated with regards to their default risk adjusted returns
- Minimum risk portfolio: combination of assets that reduces portfolio risk to lowest feasible level

Bank Portfolio Diversification



MPT Calculations

Expected Return:

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

Variance:

$$\sigma_p^2 = \sum_{i=1}^{n} X_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} X_i X_j \sigma_{ij}$$

$$\sigma_p^2 = \sum_{i=1}^{n} X_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq j}}^{n} X_i X_j \rho_{ij} \sigma_i \sigma_j$$

Example

Suppose that an FI holds two loans with the following characteristics:

Loan	Weight	Return	σ	σ^2	ρ
1	55%	8%	8.55%	73.10%	0.24
2	45%	10%	9.15%	83.72%	

Calculate the return and risk of the portfolio.

The return on the loan portfolio is: R_p = 0.55 (8%) + 0.45 (10%) = 8.90%
The risk of the portfolio is:
$\sigma_p^2 = (0.55)^2 (73.1025\%) + (0.45)^2 (83722.5\%) + 2 (0.55) (0.45) (0.24)(8.55\%)(9.15\%) = 48.36\%$
$\sigma_p = \sqrt{48.36133\%} = 69.54\%$