Best's Enterprise Risk Model:
A Value-at-Risk Approach

By
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Table of Contents

Best's Enterprise Risk Model

Based on Value-at-Risk methodology, A.M. Best and Seabury jointly created A.M. Best's Enterprise Risk Model (ERM) which should assess insurance companies' risks more accurately. Our objectives for ERM are:

- Consistent with state of art risk management concepts - Value at Risk (VaR).
- Simple and transparent methodology.
- Risk parameters are based on current market data.
- Risk parameters can be easily updated annually.
- Minimum burden imposed on insurance companies to produce inputs.
- Explicitly models country risk.
- Explicitly calculates the covariance between all of a company's assets and liabilities globally.
- Aggregates all of an insurance company's risks into a composite risk measure for the whole insurance company.

Best's Enterprise Risk Model will improve the rating process, but it will also generate some additional costs

Advantages:

- Based on historical market data
- Most data are publicly available
- Data is easily updated
- The model can be easily expanded to include more risk factors

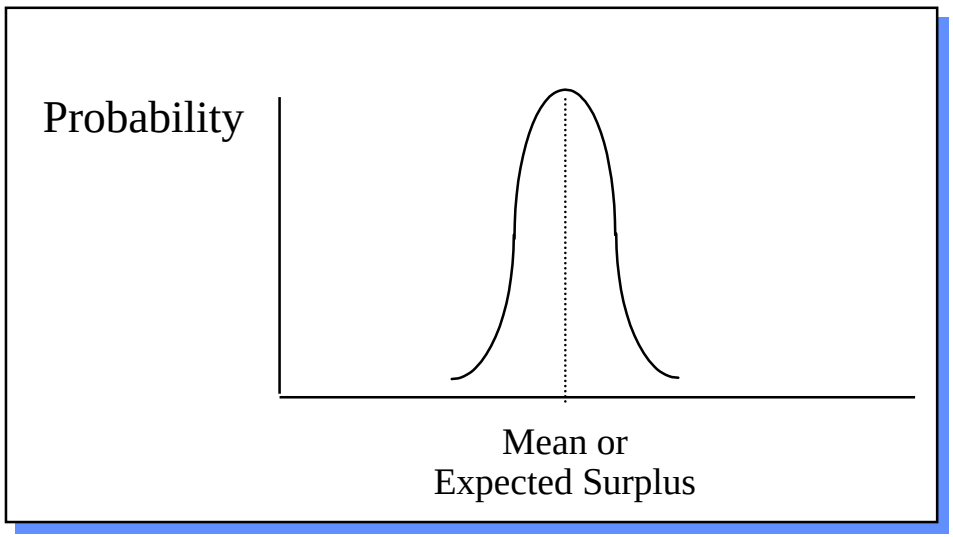
Disadvantages:

- Extra information request for the companies
- Rating analysts need to verify that the companies understand the information specifications
- Yearly update of the Variance-Covariance matrix

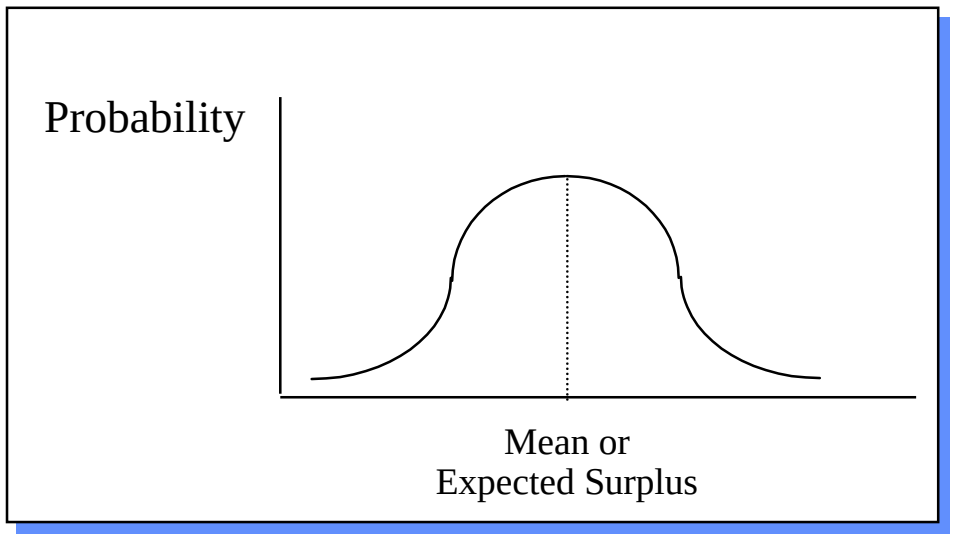
Definition of Risk

- Risk is measured in standard deviations.
- The standard deviation measures how likely an uncertain number deviates from its average or expected value.

Low Standard Deviation



High Standard Deviation



We can use this simple equation to calculate the variance of a two security portfolio:

$$\sigma_p^2 = V_a^2\sigma_a^2 + V_b^2\sigma_b^2 + 2V_a V_b \rho_{ab}\sigma_a\sigma_b$$

Where

$V = \text{value of security}$

$\sigma^2 = \text{variance}$

$\rho = \text{correlation}$

$a, b = \text{names of securities}$

However, as we increase the size of the portfolio the covariance terms increase geometrically. This formulation can be extended to the more general case of a portfolio of n assets:

$$\sigma_p^2 = \sum_{i=1}^{N}\sum_{j=1}^{N} V_i V_j \rho_{ij}\sigma_{ia}\sigma_j$$

Example

This equation can also be written in matrix form. If the variance of IBM stock is 0.09/$ and Microsoft stock is 0.25/$, and the covariance between them is 0.1.

The variance of the portfolio of $10 million of IBM stock and $5 million of Microsoft stock is:

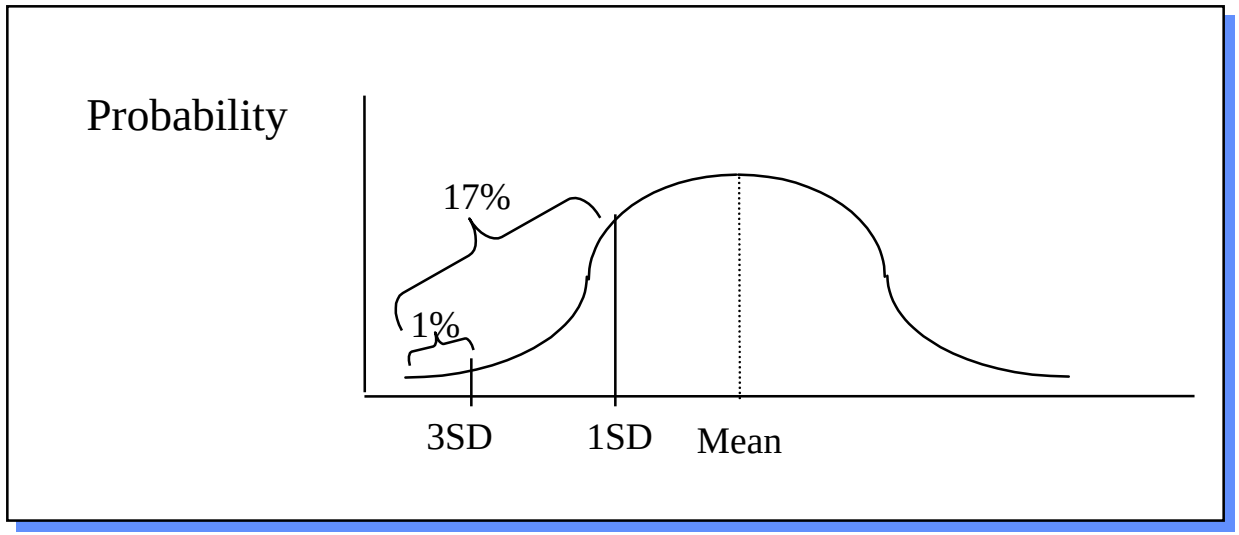
$$\begin{pmatrix} \$10M & \$5M \end{pmatrix} \begin{pmatrix} 0.09 & 0.1 \\ 0.1 & 0.25 \end{pmatrix} \begin{pmatrix} \$10M \\ \$5M \end{pmatrix} = \$25.25M$$

Value of each asset Covariance/$ among assets Variance/$ of each assets

The standard deviation of the portfolio is square root of $25.25 million, or $5.02 million.

Example - Continued

The risk of the portfolio is measured by the size of its net worth relative to its standard deviation. If the portfolio has no debt, its has about 3 standard deviations of capital, and about 1% chance of having no value.



($15M-$0)/$5.02M = 3

($15M-$10M)/$5.02M = 1

If the portfolio is funded by $10 million of debt, it has 1 standard deviation of capital, and about 17% chance of default.

Risk Categories of Insurance Companies

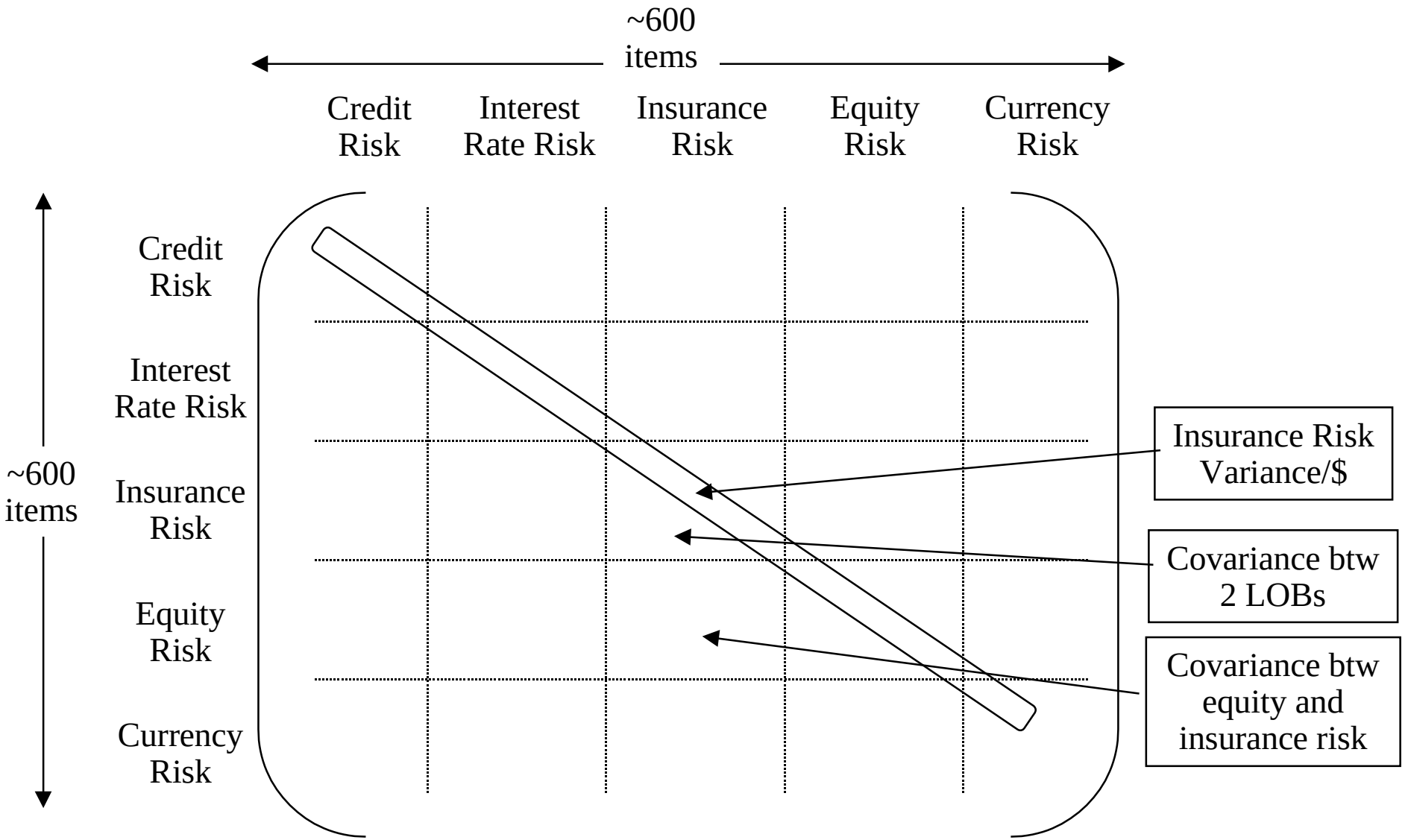
Best's Enterprise Risk Model includes the following categories of risk:

Risk Categories	Definitions	Factors
Credit risk:	The uncertainty in net worth associated with the change of the asset rating.	• Rating of assets. • Rating of reinsurers.
Interest rate risk:	The uncertainty in net worth associated with the change of interest rates in future.	• Asset and liability duration. • Reserve duration. • Duration matching.
Insurance risk:	The uncertainty in net worth associated with future insurance liabilities	• Size and types of insurance written. • Size and type of insurance reserve.
Equity risk:	The uncertainty in net worth associated with the risk of equity market valuation	• Publicly traded equity holdings. • Private equity holdings. • Project financing.
Currency risk:	The uncertainty in net worth associated with future exchange rates	• Assets and liabilities held in foreign currencies. • Insurance operations held in foreign currency. • Currency matching.

To capture the risk exposure in more details, each of these five broad risk categories can be further divided into many sub categories:

Broad Risk Category	Sub Category
Credit Risk	By rating, by country, by industry sector. E.g. German 'A' rated bond issued by financial service sector.
Interest Rate Risk	By duration, by country. E.g. British bonds in 3 years duration
Exchange Rate Risk	By country. E.g. the risk of the exchange rate of Singapore dollar / Japanese Yen
Equity Risk	By country, by industry sector. E.g. stock from Italian utility industry
Liability Risk	By country, by line of business. E.g. Private Auto in Mexico

Best's Enterprise Risk Model's Variance-Covariance Matrix



Best's Enterprise Risk Model analyzes the magnitude and the co-movements of each type of risk. To do so, the model first dissects the risk exposure of the assets (and liabilities) into several risk types.

For example:

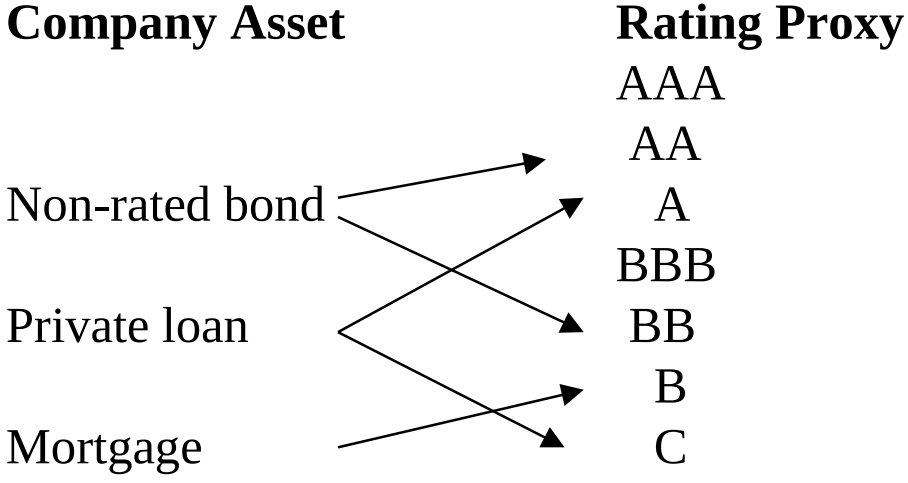
	Credit Risk	Interest Rate Risk	Exchange Rate Risk	Equity Risk	Liability Risk
Risk-free bond		✓			
Foreign risk-free bond		✓	✓		
Foreign risky bond	✓	✓	✓		
Commons stock				✓	
Convertible preferred stock				✓	
Non-convertible preferred stock	✓	✓	✓		
Convertible bonds	✓	✓		✓	
Receivables	✓	✓			
Insurance Underwriting		✓			✓

Non public Assets

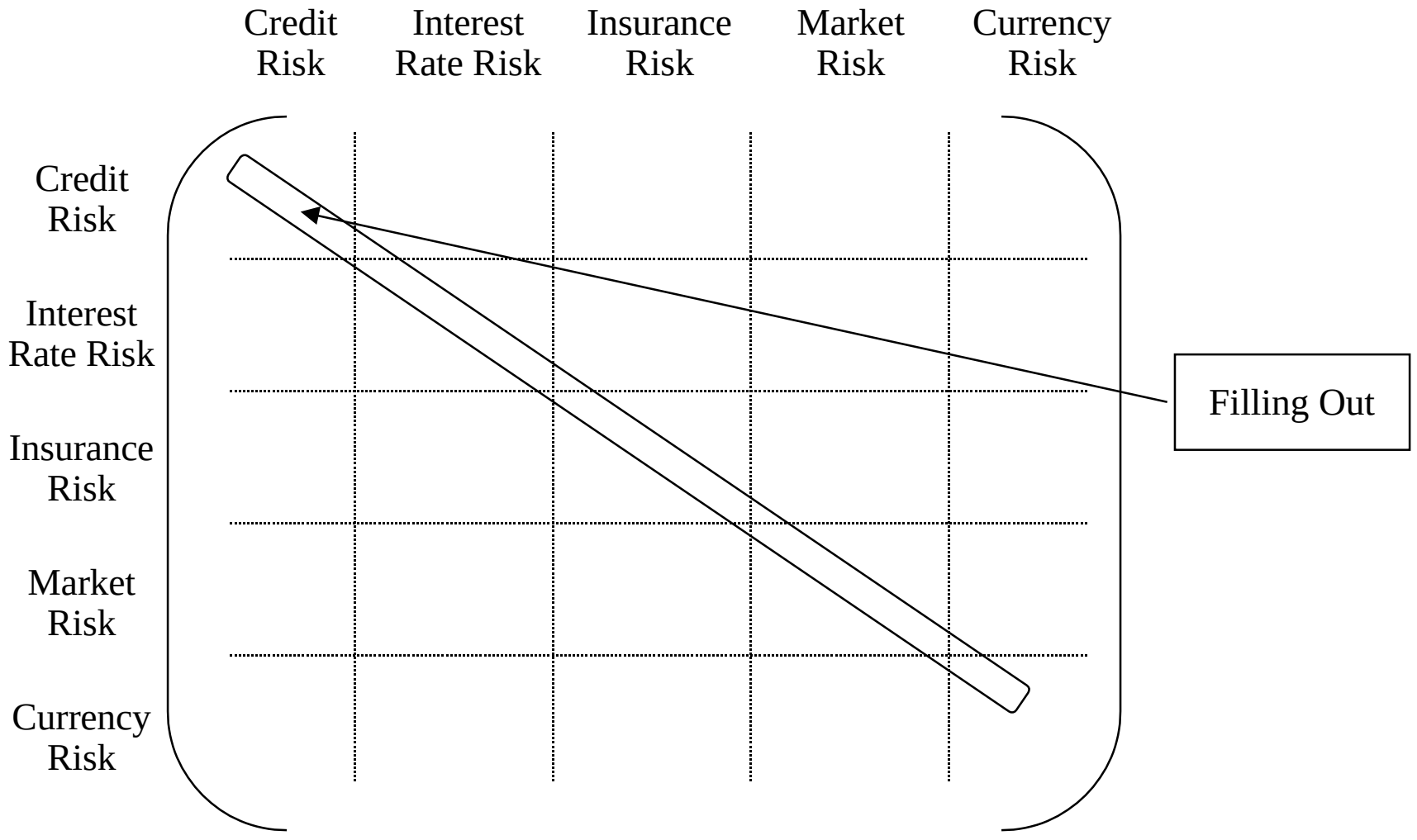
Identify the historical rates of default for non-rated bonds, private loans and mortgages.

	Default percentage
Non-rated bond	
Private loan	
Mortgage	

Example: Assume a ‘B’ rated bond has a 3% default rate. If the private loan portfolio also has a 3% default rate, it would be rated ‘B’. This process assigns a rating to non-rated bonds as below.

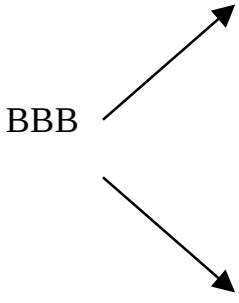


Filling Out Credit Risk



Variance of Credit Risk

The Rating Transition Matrix* summarizes the historical pattern of migration for bond ratings. For example, a BBB bond may be upgraded or downgraded with the following probability:

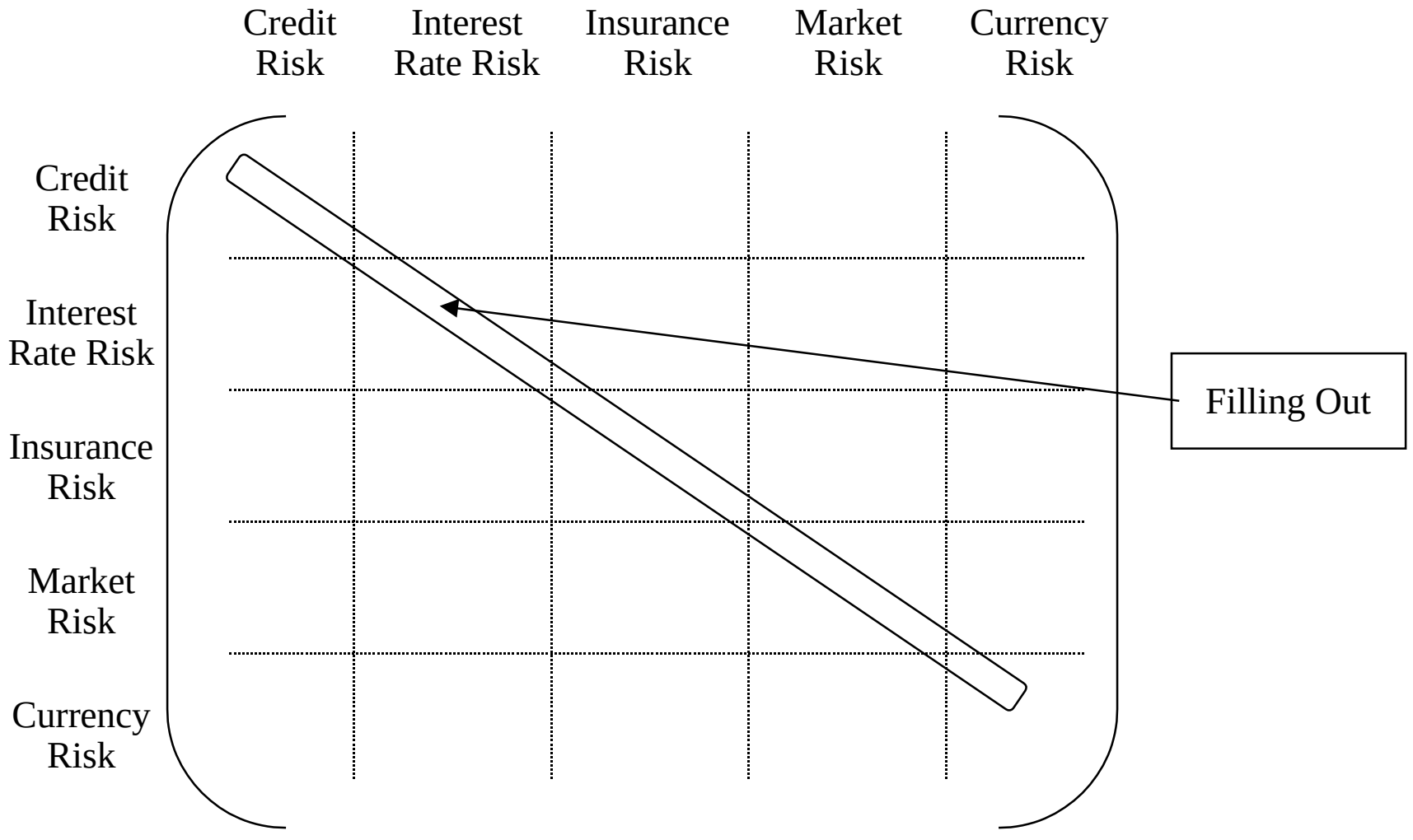


Current Rating	Possible Future Rating	Probability	Resulting Value
BBB	AAA	0.02%	$ 101.69
	AA	0.33%	$ 101.47
	A	5.95%	$ 101.03
	BBB	86.9%	$ 100.00
	BB	5.30%	$ 94.86
	B	1.17%	$ 91.21
	C	0.12%	$ 77.77
	D	0.18%	$ 47.54

Given the range of possible values and probability, we can calculate the variance of the future value of a BBB bond. In this case, the variance is 8.9477. The entry for BBB rating bond's variance is 8.9477**.

*Obtained from CreditMetric. ** See Appendix for formula

Filling Out Interest Rate Risk



Variance of Interest Rate Risk

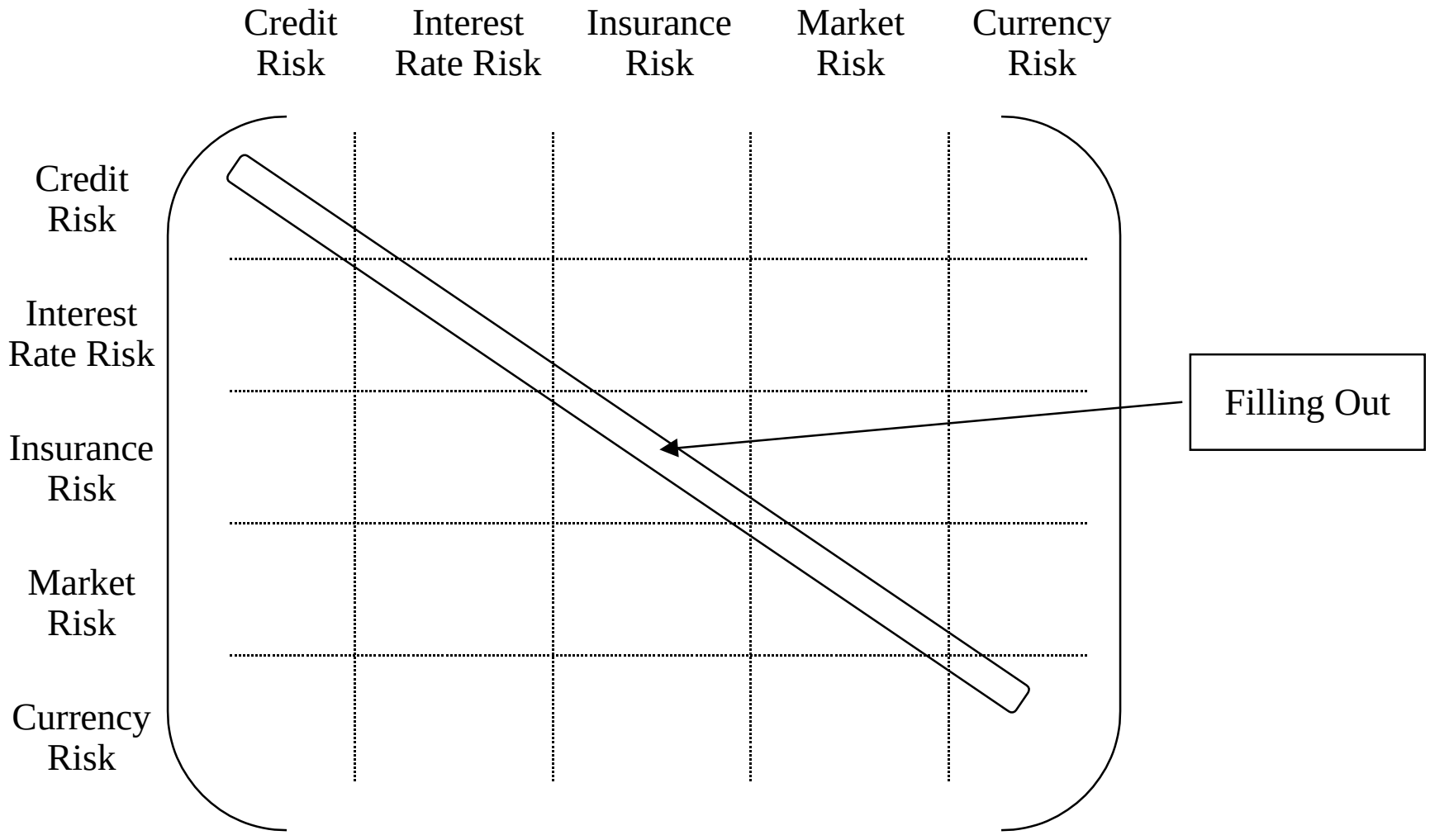
Obtain the historical interest rates and calculate the corresponding bond values. The interest rate risk is manifested in the variance of the bond value. Repeat the process for bonds of different durations

	Duration=1		Duration=5	Duration=10
Time	**Interest Rate**	**Bond Value**		
Day 1	**5.0%**	**$100**		
Day 2	**5.1%**	**$99**		
…	**…**			
Day N	**7%**	**$90**		
Std Deviation		**$5.35**		

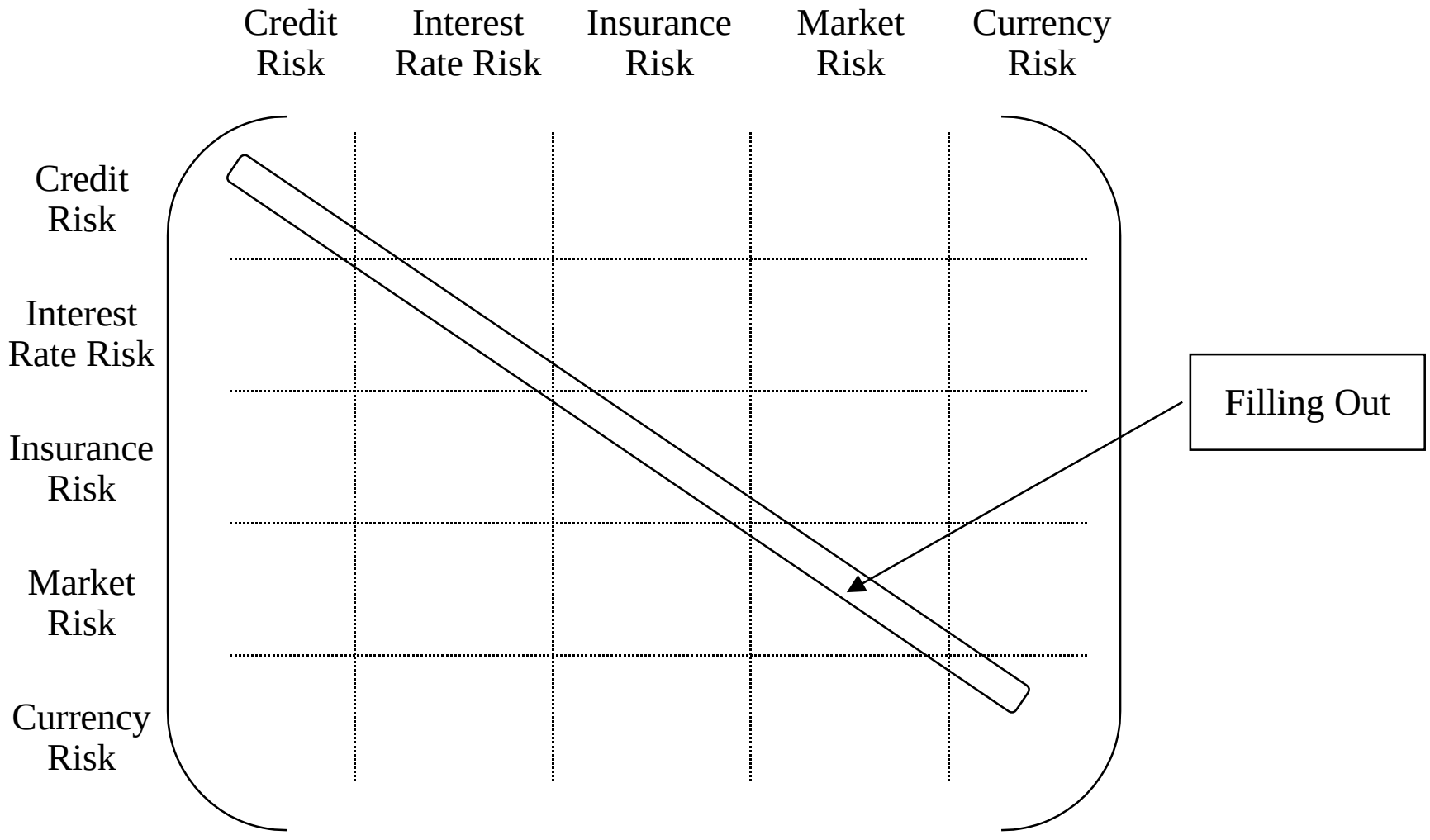
Example:

A good proxy for the 1-year interest rate risk is a money market instrument with a 1-year maturity. The standard deviation of the value a 1-year money market instrument in Singapore is 5.35%. So the entry for variance is 0.0028623

Filling Out Insurance Risk

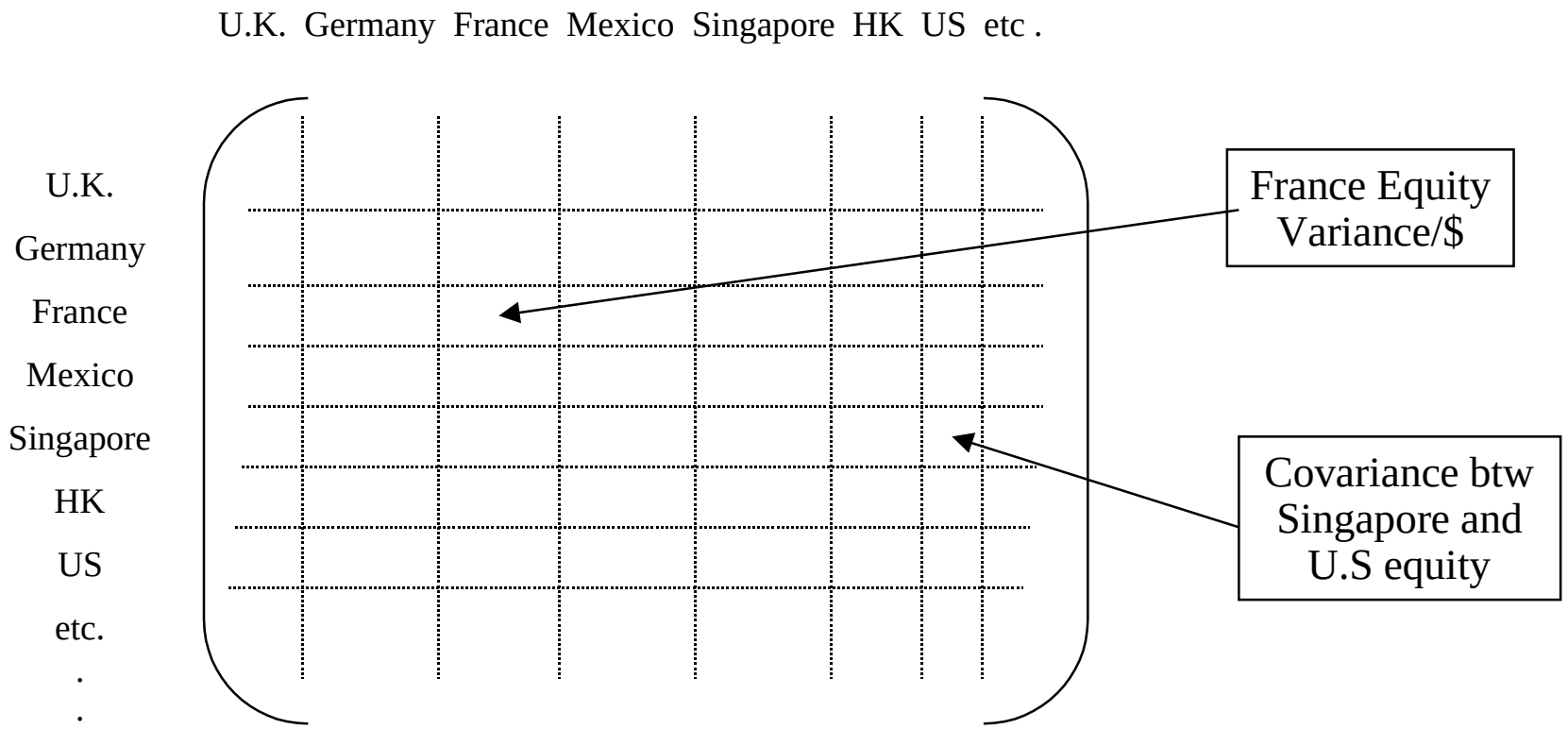


Filling Out Market Risk

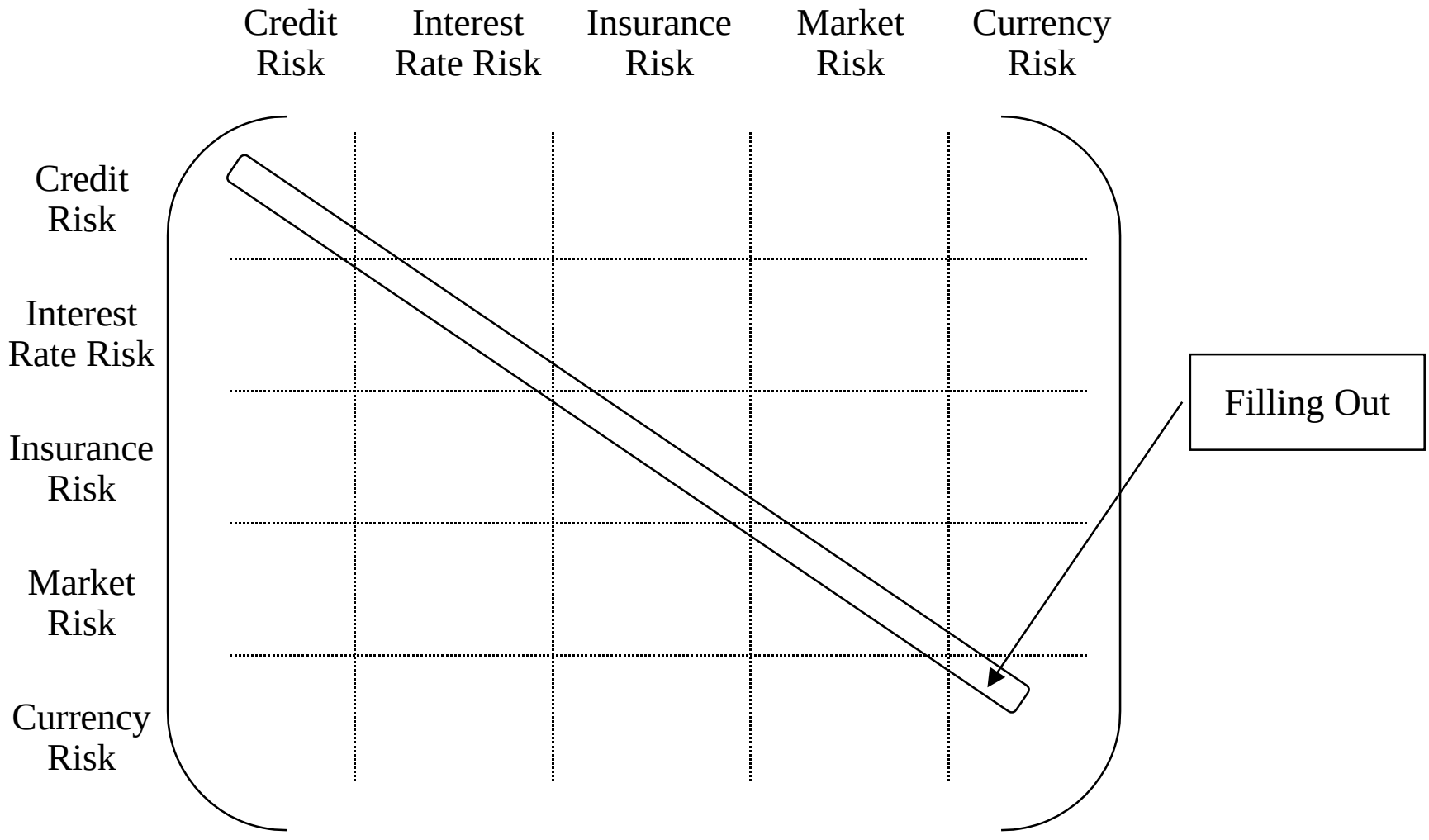


Variance of Market Risk

The variance and covariance of market risk can be estimated using the historical return on equity index. In general, we can assume each country has ten sectors.



Filling Out Currency Risk



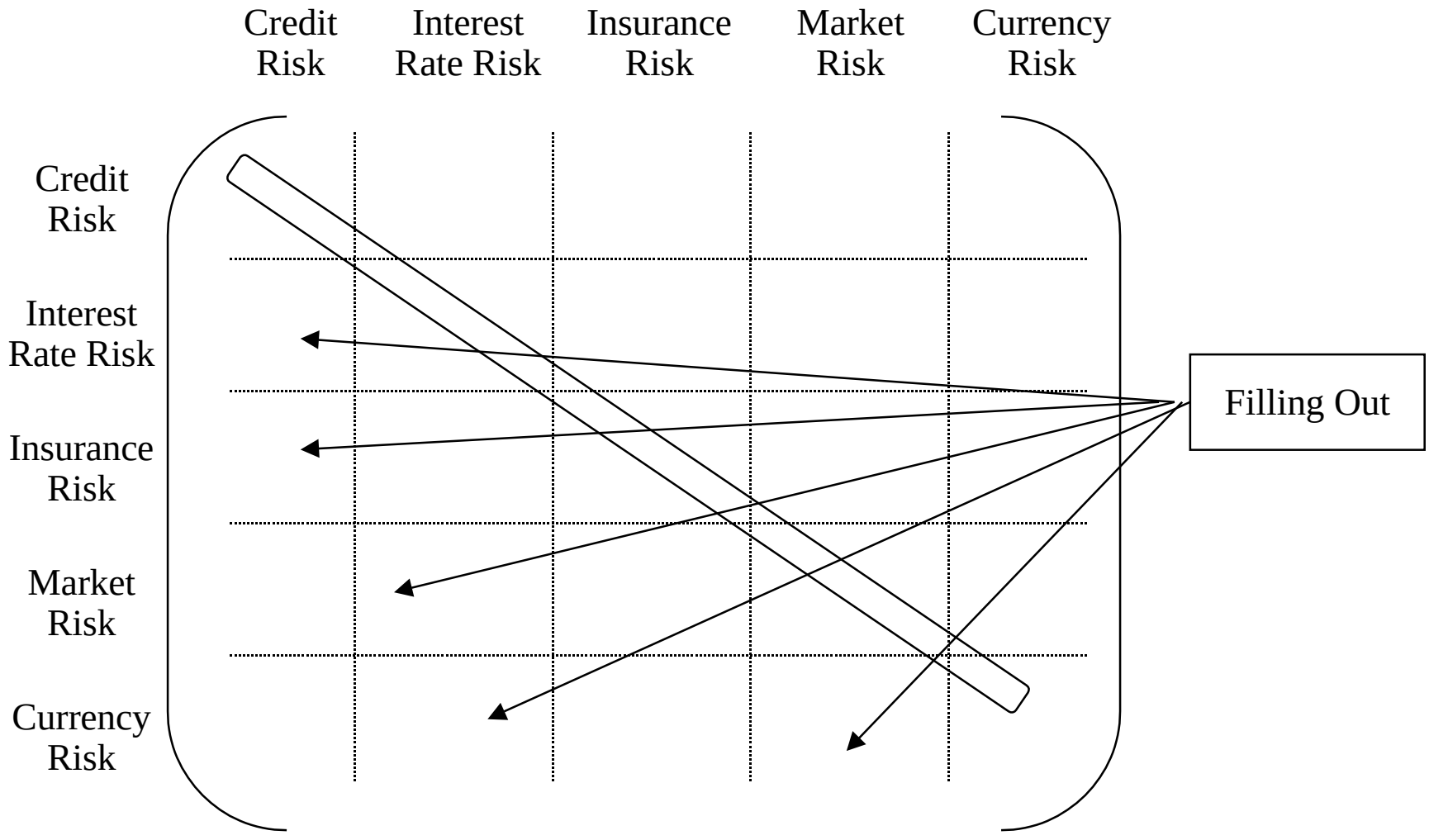
Variance of Currency Risk

Use historical currency rates to estimate the risk of holding assets or liabilities in foreign currency

Time	HK$/S$	US$/S$	Yen/S$	…..
Day 1				
Day 2				
…				
Day N				
Variance				

Example:
The variance of US$/S$ exchange rate is 0.00162.

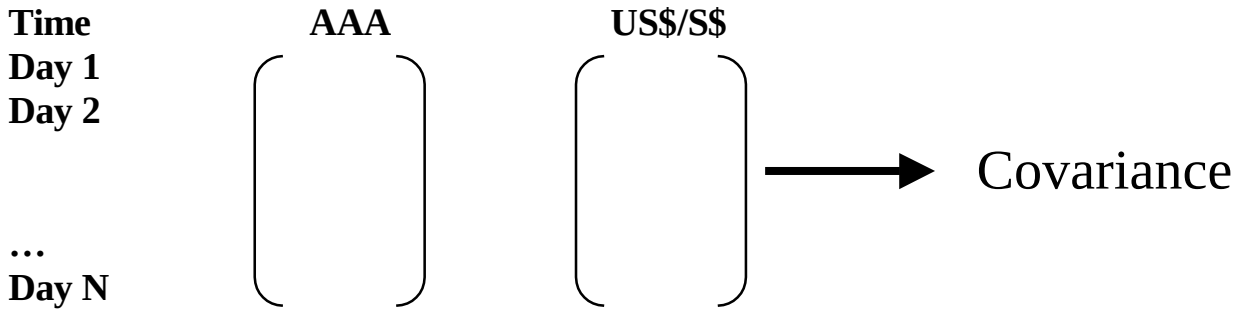
Filling Out Covariance Risk



Estimating Covariance Risk

An institution's Covariance Risk can be defined as the resilience of its net worth to extreme market movements. Institutions with greater diversification should experience less vulnerability to covariance risk. The model's covariance matrix can measure the uncertainty between any two kinds of risk.

For example, if we want to find out whether the 'US dollar / Singapore dollar' exchange rate and credit risk (of AAA bond) move together, we put the historical data of the two series together and calculate its covariance



Diversification Benefits Within A Risk Class

Holding many assets and selling many policies in one risk class can also produce diversification benefits. We can adjust the diversification benefits in a portfolio by the weights of assets or liabilities within the same risk category. In the following example, we quantify the benefit of holding many assets.

Example:

Company 1 invests $1 in just one bond. Suppose the variance of the bond is 1, then the risk of the bond is $1.

Company 2 invests in 100 bonds each for $1/100. Suppose the correlation between all the bonds is 0.3, then the total risk becomes $0.55

To adjust for diversification benefits, we can multiply this factor (0.55) by the asset allocation.*

*See appendix for formula

Table of Contents

Example - Multi-Line Company

Here is a simplified example:

Assume the company writes two lines of business: Individual Health and Homeowners. It also has two assets: S&P 500 Index fund and an 'A' rated bond with 10 years duration.

	Exposure
Individual Health	$500 in premium
Homeowner	$800 in premium
S&P 500 Index	$500
'A' rated 10 year duration bond	$1000

Example - Total Risk Before Diversification

- Risk exposures are mapped into risk sub categories-rows 1-4
- Total risk exposures are listed in row 5.
- From market prices, the model calculates the risk parameters (e.g., contribution to the capital standard deviations per $ of exposure) for each risk sub-category from the market data-row 6.
- Risk exposures by category and before diversification are then calculated in row 7.
- The total standard deviation for this company before the diversification benefit is $849.93

Row		Exposure	A rated credit	Interest rate 1 year duration	Interest rate 10 year duration	Health	Homeowner	US Equity	Foreign Exchange
1	Individual Health	$500		$500		$500			
2	Homeowner	$800		$800			$800		
3	S&P500	$500						$500	
4	10 year duration A rated Bond	$1,000	$1,000		$1,000				
5	Total Risk Exposure (sum of row 1 to 4)		$1,000	$1,300	$1,000	$500	$800	$500	0
6	Risk per $ in Exposure		7.1%	5.0%	19.5%	23.5%	30.0%	32.4%	20.0%
7	Risk Exposure in $ (row 5 multiply row 6)		$70.71	$65.00	194.94	$117.26	$240.00	$162.02	$-
8	Total Risk Before Diversification								$849.93

Example - Diversification Benefits

We calculate the correlation between these risk sub categories from the market data, and assume the results are as follows:

Illustration

	Credit	1 year duration interest	10 year duration interest	Health	Homeowner	US Equity	ForEx
credit	1	-0.5	0.3	0.1	0.1	0.8	0.3
1 year duration	-0.5	1	-0.7	-0.7	-0.8	-0.6	-0.1
10 year duration interest	0.3	-0.7	1	0.7	0.7	0.8	0.1
Health	0.1	-0.7	0.7	1	0.3	0.2	0.2
Homeowner	0.1	-0.8	0.7	0.3	1	0.2	0.2
US Equity	0.8	-0.6	0.8	0.2	0.2	1	0.5
ForEx	0.3	-0.1	0.1	0.2	0.2	0.5	1

Remember that a correlation of 1 means the risk categories always move together, -1 means they always move in opposite directions, 0 means no relationship.

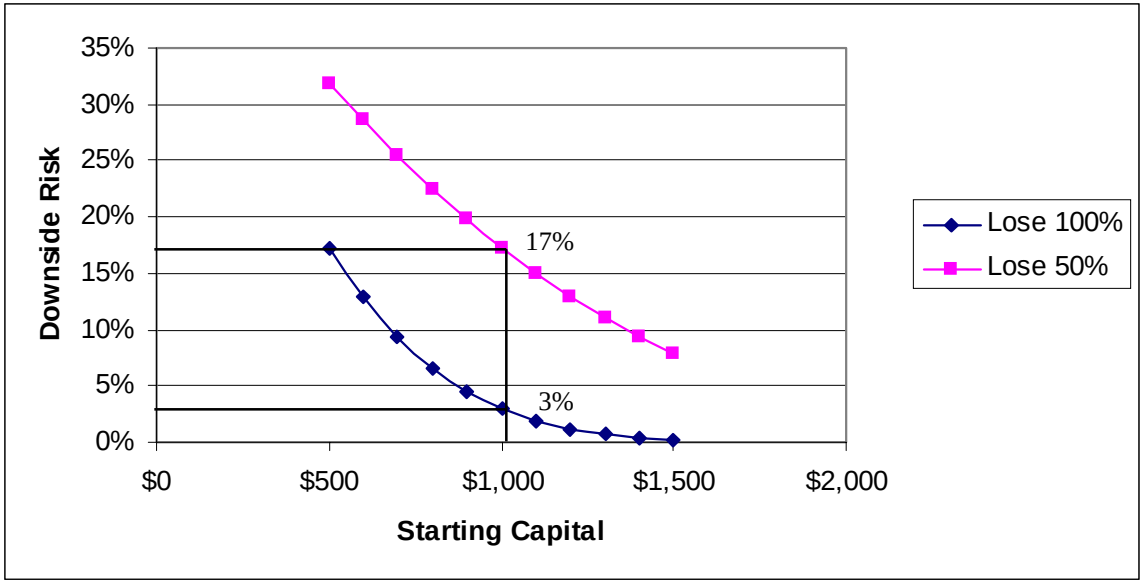
Given the correlation structure, we calculate a total diversification benefit of $319.68. The total standard deviation of this company is $849.93 - $319.68 = $530.25.

Example - Risk Score and Downside Risk

If this company has $1,000 of surplus and risk of $530, its capital adequacy score is 1.89.

$$\frac{\$1{,}000}{\$530.25} = 1.89$$

This score represents a company's relative capital strength. Companies with higher scores should have greater capital strength and less chance of default.



If we also assume the enterprise risk of this company is normally distributed (not an unreasonable assumption in most cases), we can imply that the probability of default within one year is around 3%. The probability of losing 50% of its capital is around 17%.

Example - Managerial Questions

The model provides the basis to explore more important issues, such as:

- What is the RAROC of the Health and Homeowner divisions?
- How should the company allocate its $1,000 of surplus between the Health and Homeowner businesses?
- Are these businesses creating value or destroying value?
- What can be done to improve the investment strategy? Should the company invest in S&P 500 index?
- What can be done to improve the business strategy? Should the company increase the weight of Health? Should the company buy an Auto company for diversification?

Example - Change in Asset Portfolio

- Assume the company sells the 10 year A-rated bond and reinvests in cash
- Risk exposures by category and before diversification are then calculated in row 7.
- The total standard deviation for this company before the diversification benefit is $584.28

Row		Exposure	A rated credit	Interest rate 1 year duration	Interest rate 10 year duration	Health	Homeowner	US Equity	Foreign Exchange
1	Individual Health	$500		$500		$500			
2	Homeowner	$800		$800			$800		
3	S&P500	$500						$500	
4	10 year duration A rated Bond	$0	$0		$0				
5	Total Risk Exposure (sum of row 1 to 4)		$0	$1,300	$0	$500	$800	$500	0
6	Risk per $ in Exposure		7.1%	5.0%	19.5%	23.5%	30.0%	32.4%	20.0%
7	Risk Exposure in $ (row 5 multiply row 6)		$0	$65.00	$0	$117.26	$240.00	$162.02	$-
8	Total Risk Before Diversification								$584.28

Example - Diversification Benefits

We calculate the correlation between these risk sub categories from the market data, and assume the results are as follows:

Illustration

	Credit	1 year duration interest	10 year duration interest	Health	Homeowner	US Equity	ForEx
credit	1	-0.5	0.3	0.1	0.1	0.8	0.3
1 year duration	-0.5	1	-0.7	-0.7	-0.8	-0.6	-0.1
10 year duration interest	0.3	-0.7	1	0.7	0.7	0.8	0.1
Health	0.1	-0.7	0.7	1	0.3	0.2	0.2
Homeowner	0.1	-0.8	0.7	0.3	1	0.2	0.2
US Equity	0.8	-0.6	0.8	0.2	0.2	1	0.5
ForEx	0.3	-0.1	0.1	0.2	0.2	0.5	1

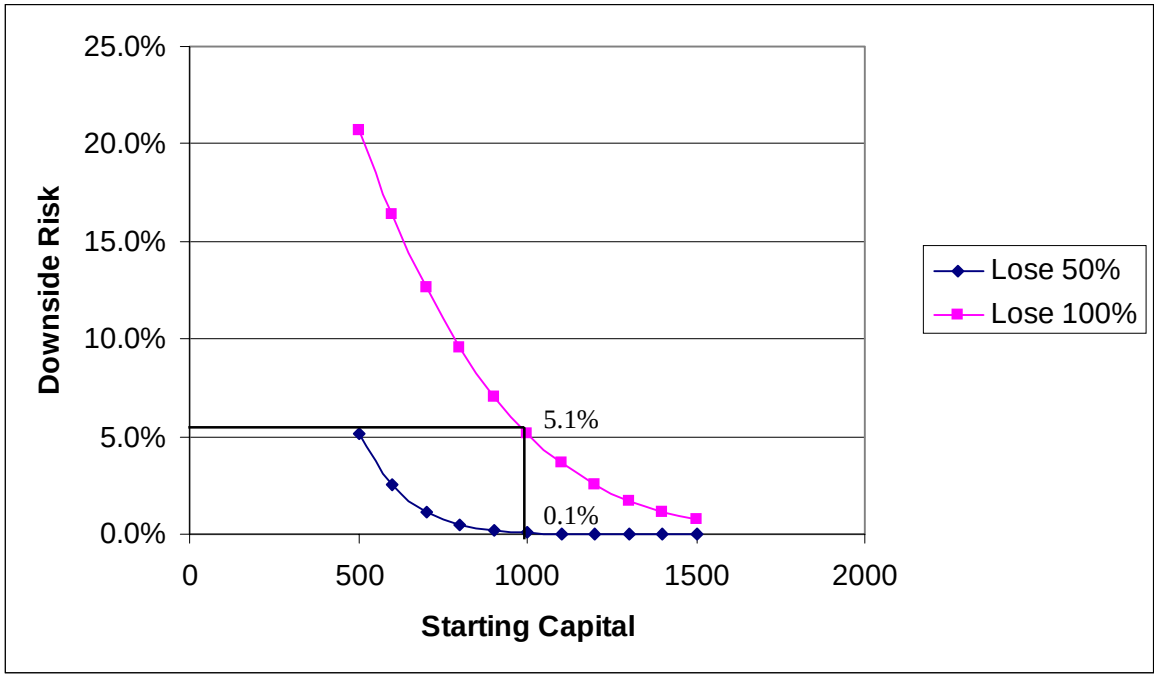
Remember that a correlation of 1 means the risk categories always move together, -1 means they always move in opposite directions, 0 means no relationship.

Given the correlation structure, we calculate a total diversification benefit of $278.35. The total standard deviation of this company is $584.28 - $278.35 = $305.93.

Example - Risk Score and Downside Risk

If this company has $1,000 of surplus and risk of $305.93, its capital adequacy score is 3.27.

$$\frac{\$1{,}000}{\$305.93} = 3.27$$



If we also assume the enterprise risk of this company is normally distributed (not an unreasonable assumption in most cases), we can imply that the probability of default within one year is around 0.1%. The probability of losing 50% of its capital is around 5.1%.

Table of Contents

The Enterprise Risk Model can provide many capabilities for rating agencies and regulators. There are at least three applications of this risk management model:

- Rank all companies in terms of downside risk
- Breakdown of risk by categories
- Links risk score to bond ratings

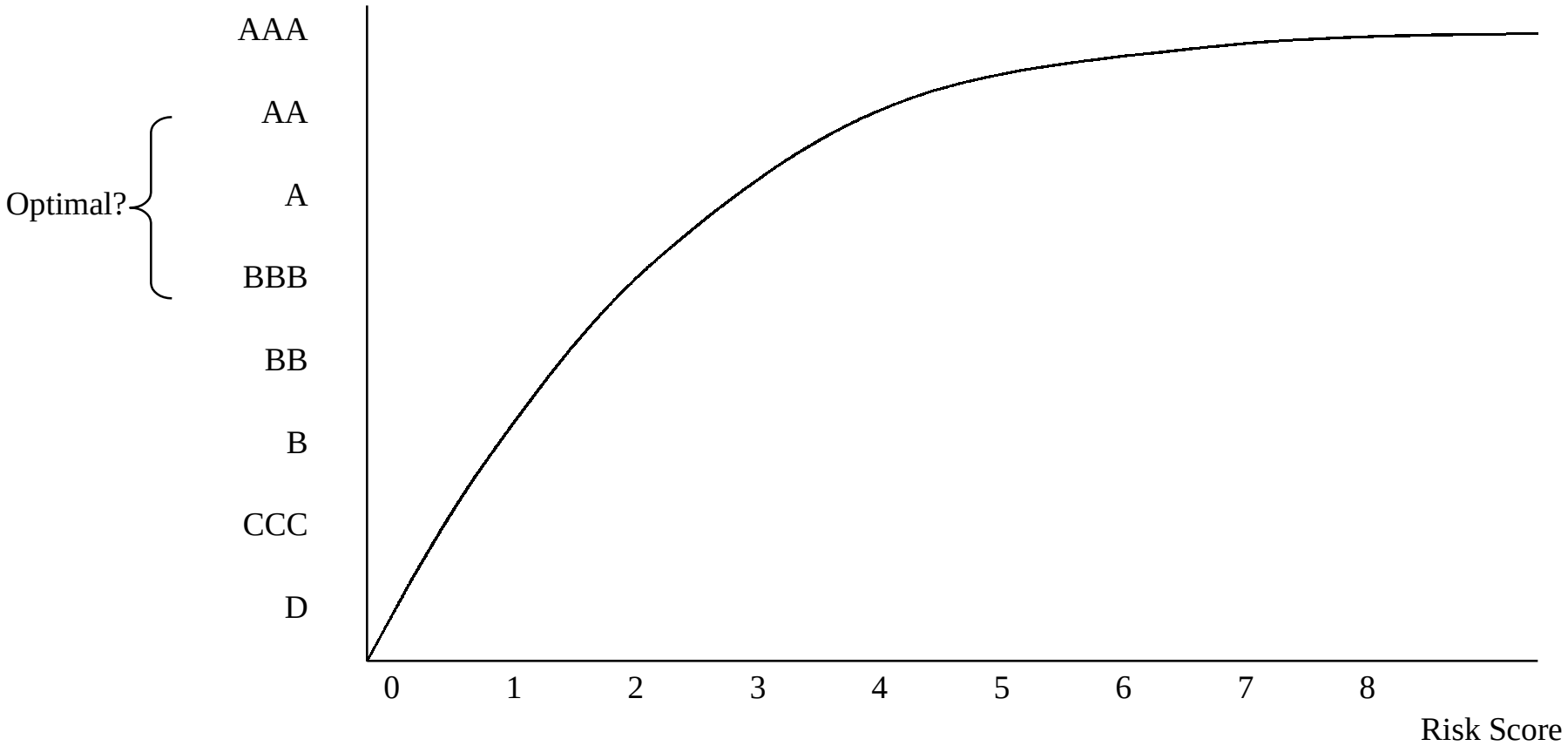
The Enterprise Risk Model can rank all the regulated companies using the Risk Score. The risk score identifies the relatively weak companies.

Company	Capital	Risk	Risk Score
1	$ 5,268	$ 985	5.35
2	$ 55,841	$ 10,254	5.45
3	$ 125,330	$ 28,564	4.39
:			
:			
1000	$ 3,569	$ 5,874	0.61
Average			3.58
75th Percentile			4.05
25th Percentile			2.55

The Enterprise Risk Model can provide the normal breakdown by risk categories. It identifies companies with abnormal risk exposure patterns.

	Life Insurance			P&C Insurance		
	Average	Top 75%	Top 25%	Average	Top 75%	Top 25%
Credit risk:	23%	55%	12%	5%	8%	2%
Interest rate risk:	41%	65%	22%	26%	50%	14%
Insurance risk:	5%	8%	3%	63%	85%	44%
Equity risk:	29%	45%	10%	5%	9%	2%
Currency risk:	2%	5%	1%	1%	3%	1%

The Enterprise Risk Model can link companies' financial strength to a common bond rating.



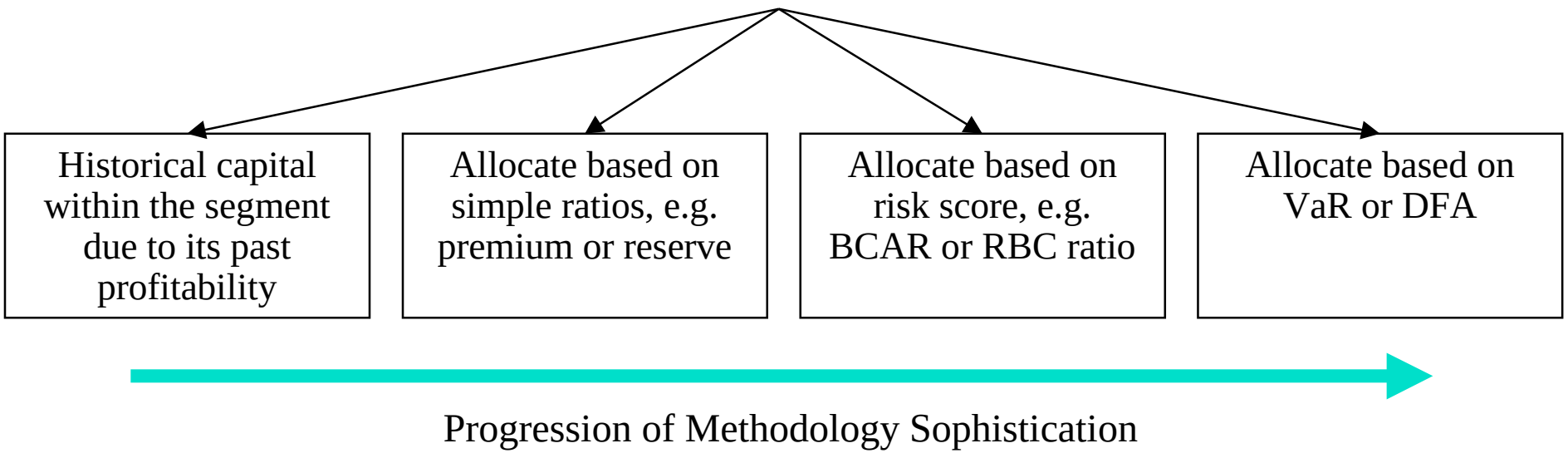
One of the objectives of Best's Enterprise Risk Model is to provide value-added to A.M. Best's clients. The Enterprise Risk Model can be customized to provide many capabilities beyond rating maintenance. There are at least six applications of this risk management model:

- Capital allocation and performance measurement
- Model the risk and return consequences of M&A activity
- Trace the sources of risk and diversification benefits
- Achieve an optimal risk-reward balance
- Managing downside risk
- Stress test for financial crisis'

Capital Allocation and Performance Measurement

- A popular segment profitability model is RAROC, risk adjusted return on capital
- Segment RAROC is accurate only if capital is accurately allocated to the segment.

$$\text{Segment RAROC} = \frac{\text{Segment Net Income}}{\text{Segment Allocated Capital}}$$



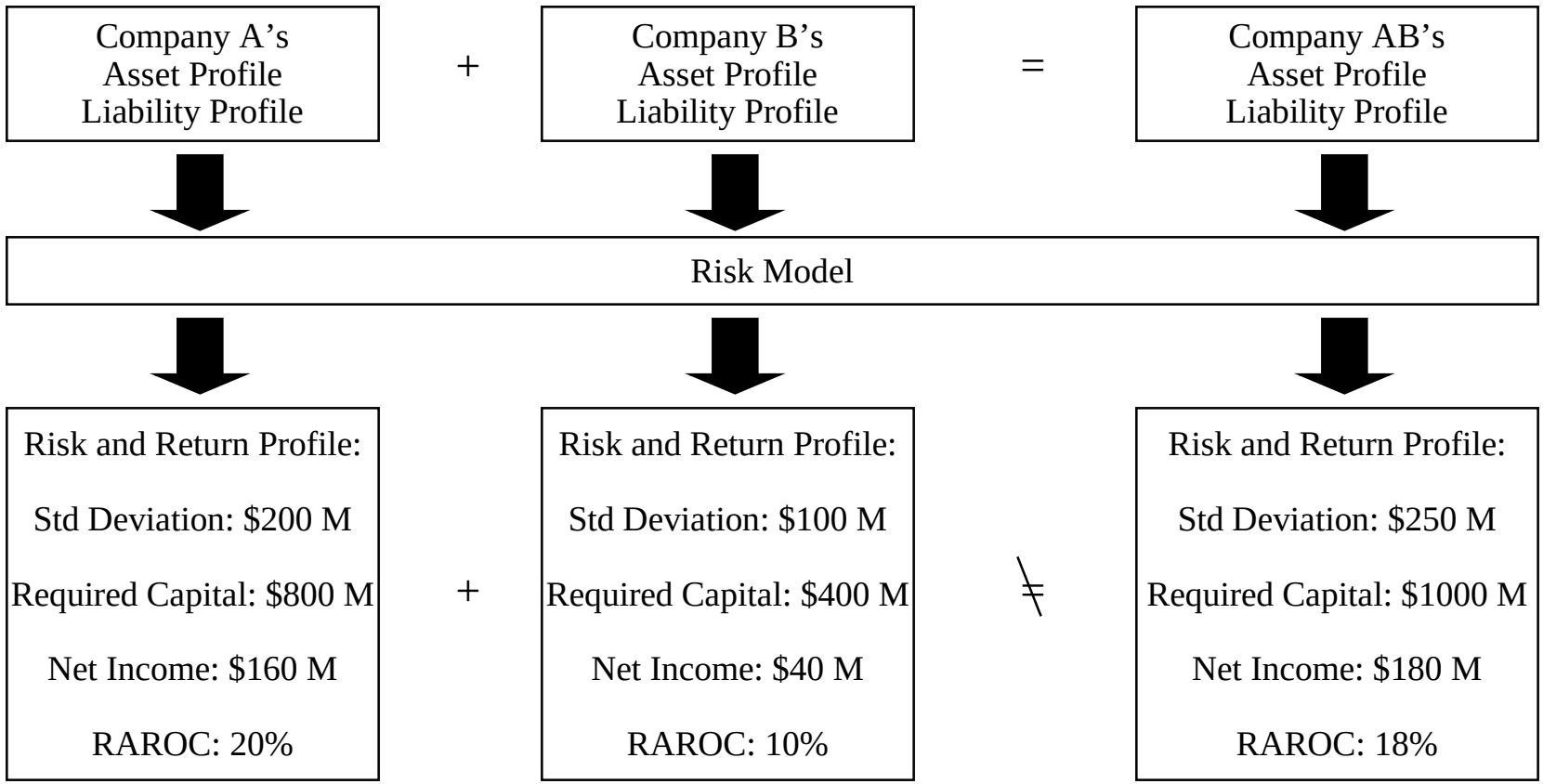
The first step of managing shareholder value is to measure the relative contribution to shareholder value from each business activity

	Required Capital	% of Total Capital	Premium	Income	RAROC	Capital Cost (10%)	EVA (%)	EVA ($)
LOB #1	$70M	18%	$233M	$14M	19.7%	$7M	**9.7%**	**$7M**
LOB #2	$191M	50%	$337M	$8M	3.9%	$19M	**(6.1%)**	**($12M)**
LOB #3	$20M	5%	$126M	$2M	10.7%	$2M	**0.7%**	**$0**
LOB #4	$41M	11%	$64M	$4M	9.7%	$4M	**(0.3%)**	**$0**
LOB #5	$61M	16%	$138M	$9M	14.9%	$6M	**4.9%**	**$3M**
TOTAL	$385M	100%	$897M	$37M	9.5%	$38M	**0.5%**	**($2M)**

Our results showed that LOB #2 was using significantly more capital than what the client initially believed. It is an undesirable business because it consumes all the EVA earned by the other lines of business.

Model Risk and Return Consequences of M&A Activities

The customized model will provide an important insight concerning the adjusted capital that will be required when one company buys another company or sells some of its businesses.



Trace the Sources of Risks and Diversification Benefits

- The customized model allows management to calculate the total risk of the company or of a segment, and also to identify the sources of the risk. Our experience tells us that most of the sources of risk are not intuitively clear until they are modeled. Sometimes these risks can be eliminated at very little or no cost once they are identified.

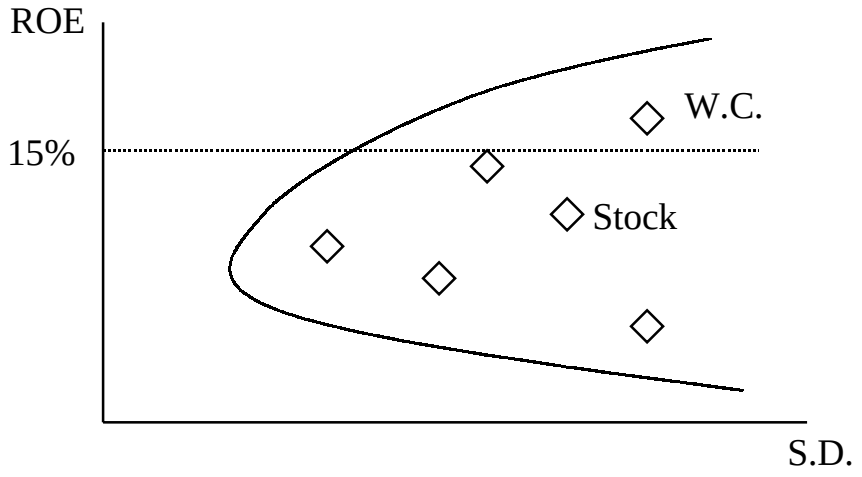
- The size of the diversification benefit may be as high as one-half of the total VaR. Clever management of the diversification benefit will eliminate a lot of the risk and capital requirement.

Achieve Optimal Risk-Reward Balance

The original purpose of Portfolio Theory was to help investors balance the risk and reward of their portfolio by sorting out the complicated co-movement of all the assets in the portfolio.

The same process can be applied to an insurance company. For example, if the company's objective is to maintain an ROE of 15% while maintaining 3 standard deviations of capital, the customized model can deduce its asset mix requirements given the following constrains:

- Workers comp has to be constrained to 40% if total premium, and
- The stock portfolio must be constrained to, at most, 20% of total assets, etc.



Managing Downside Risk

For most firms, default is not an imminent event. However, downside risk can be defined as any undesirable event, for example:

- Negative operating earnings
- Lose 25% of capital
- Lose 50% of capital
- Rating downgrade

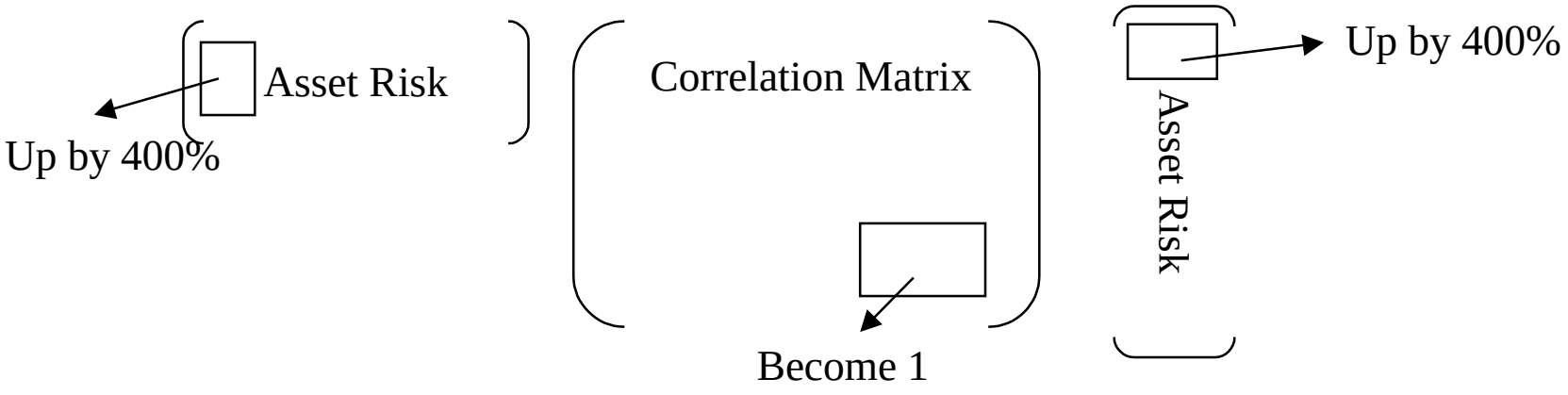
The customized model will estimate the probability of these events. In addition, the model will let management identify the causes of these risks thereby providing the means to avoid them.

Surviving ‘Financial Crisis’

- VaR model calculates a company’s riskiness during the ‘current’ business climate.
  - E.g. Company X has a 0.5% chance of going bankrupt during ‘current’ business climate
  - The RiskMetric methodology defines ‘Current’ business climate as 2 years daily average risk exposure (recent events more important - decay factor of 0.97)
- The customized model can be modified to calculate a company’s riskiness during ‘financial crisis’
  - E.g. Company X has a 10% chance of going bankrupt during ‘crisis’
  - The ‘crisis’ has to be pre-determined

What is ‘Financial Crisis’

- AM Best can define a ‘crisis’:
  - E.g. credit risk is 400% more risky, foreign exchange is 500% more risky. All correlation among Asian countries becomes 1.



- Use historical Crisis
  - Define a period of time, e.g. June 1997 to August 1998 as ‘crisis’.
  - Recalculate the risk parameters with the data in the ‘crisis period’
  - Not ready

Example - Financial Crisis Stress Testing

- Risk exposures are mapped into risk sub categories-rows 1-4
- Total risk exposures are listed in row 5.
- The risk of each sub-category is increased by 400% -row 6.
- Risk exposures by category and before diversification are then calculated in row 7.
- The total standard deviation for this company before the diversification benefit is $2328

Row		Exposure	A rated credit	Interest rate 1 year duration	Interest rate 10 year duration	Health	Homeowner	US Equity	Foreign Exchange
1	Individual Health	$500		$500		$500			
2	Homeowner	$800		$800			$800		
3	S&P500	$500						$500	
4	10 year duration A rated Bond	$1,000	$1,000		$1,000				
5	Total Risk Exposure (sum of row 1 to 4)		$1,000	$1,300	$1,000	$500	$800	$500	0
6	Risk per $ in Exposure		28.3%	20.0%	78.0%	23.5%	30.0%	129.6%	80.0%
7	Risk Exposure in $ (row 5 multiply row 6)		$283	$260	$780	$117	$240	$648	$-
8	Total Risk Before Diversification								$2328

Example - Diversification Benefits

The correlation among all assets are now 1.

Illustration

	credit	1 yr duration	10 year durati	Health	Homeowner	US Equity	ForEx
credit	1	1	1	0.1	0.1	1	1
yr duration	1	1	1	-0.7	-0.8	1	1
on interest	1	1	1	0.7	0.7	1	1
Health	0.1	-0.7	0.7	1	0.3	0.2	0.2
lomeowner	0.1	-0.8	0.7	0.3	1	0.2	0.2
US Equity	1	1	1	0.2	0.2	1	1
ForEx	1	1	1	0.2	0.2	1	1

Remember that a correlation of 1 means the risk categories always move together, -1 means they always move in opposite directions, 0 means no relationship.

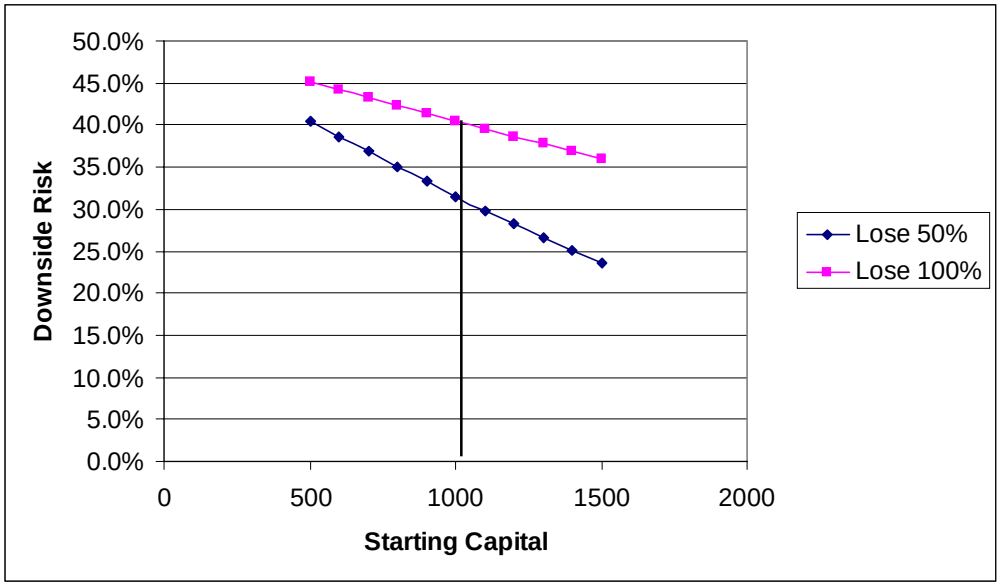
Given the correlation structure, we calculate a total diversification benefit of $247. The total standard deviation of this company is $2328 - $247 = $2081.

Example - Risk Score and Downside Risk

If this company has $1,000 of surplus and risk of $2081, its capital adequacy score is 0.48.

$$\frac{\$1{,}000}{\$2081} = 0.48$$

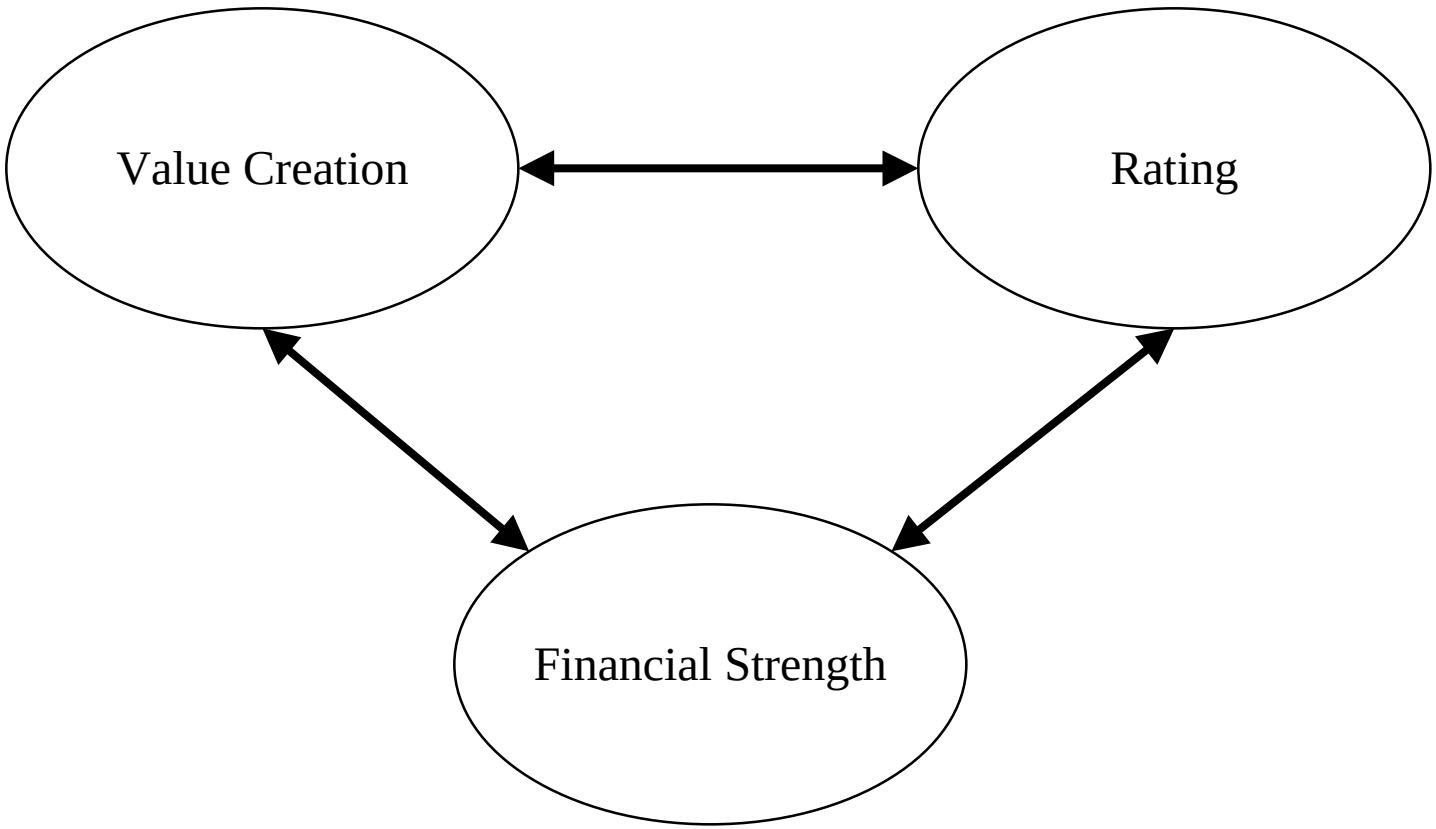
This score represents a company's relative capital strength. Companies with higher scores should have greater capital strength and less chance of default.



If we also assume the enterprise risk of this company is normally distributed (not an unreasonable assumption in most cases), we can imply that the probability of default within one year is around 31.5%. The probability of losing 50% of its capital is around 40.5%.

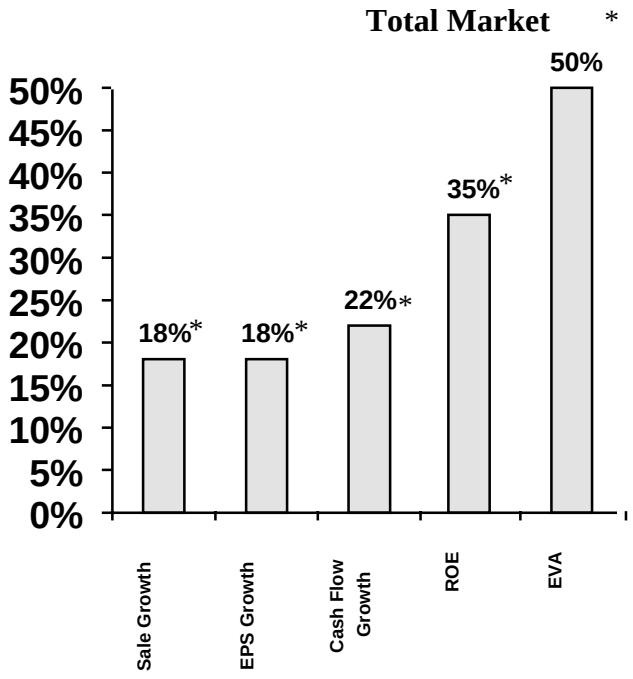
Table of Contents

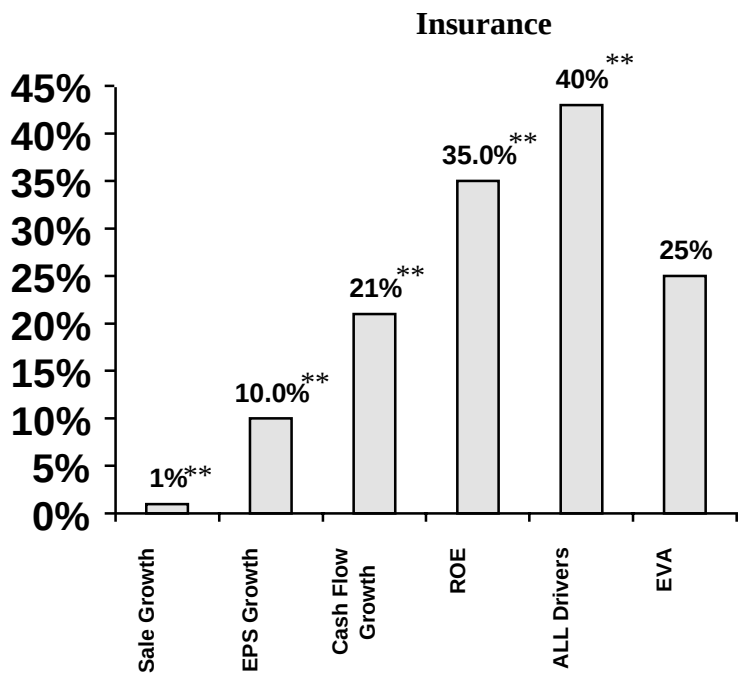
Performance Measurement And Insurance Ratings



No single conventional financial performance indicator explains shareholder value very well

% of Enterprise Value Explained

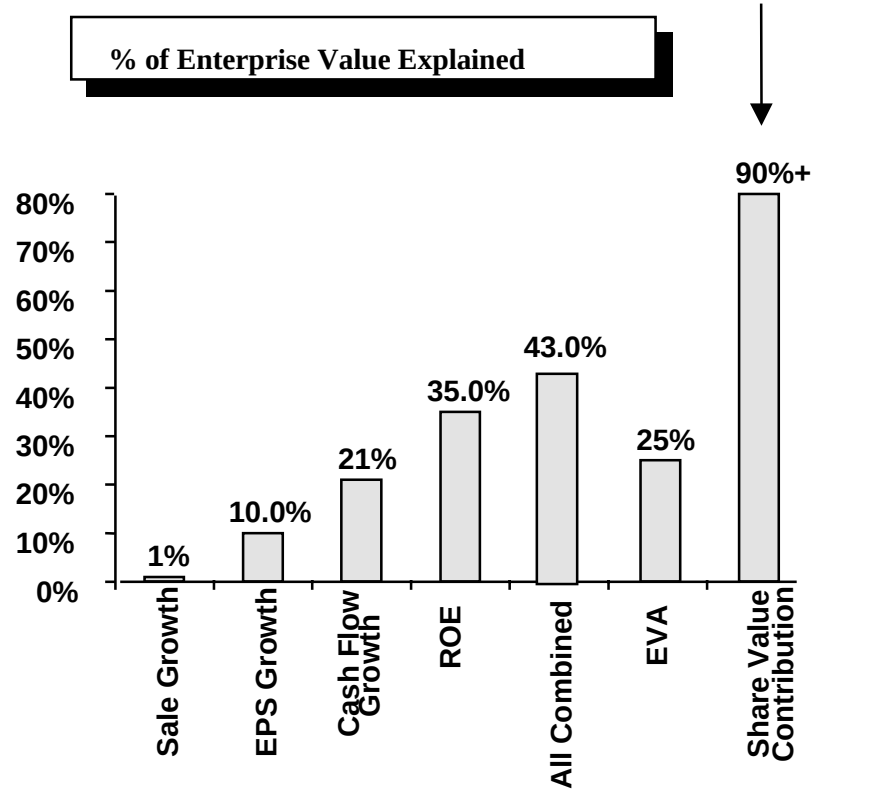




* According to Stern Stewart & Co., sample includes Stern Stewart Performance 1000.
** Based on Valueline beta and historical financial data. Sample data includes all insurance(Life and P/C) companies analyzed by Valueline

However, if a company's future cash flows are discounted by its market discount (RR), a far better estimation of market value is achieved.

$$M/B = \frac{ROE}{RR - G}$$



From Capital Allocation to Shareholder Value

Shareholder Value is not driven just by earnings and risk alone, but also by expected earnings growth. The relationship can be expressed mathematically as:

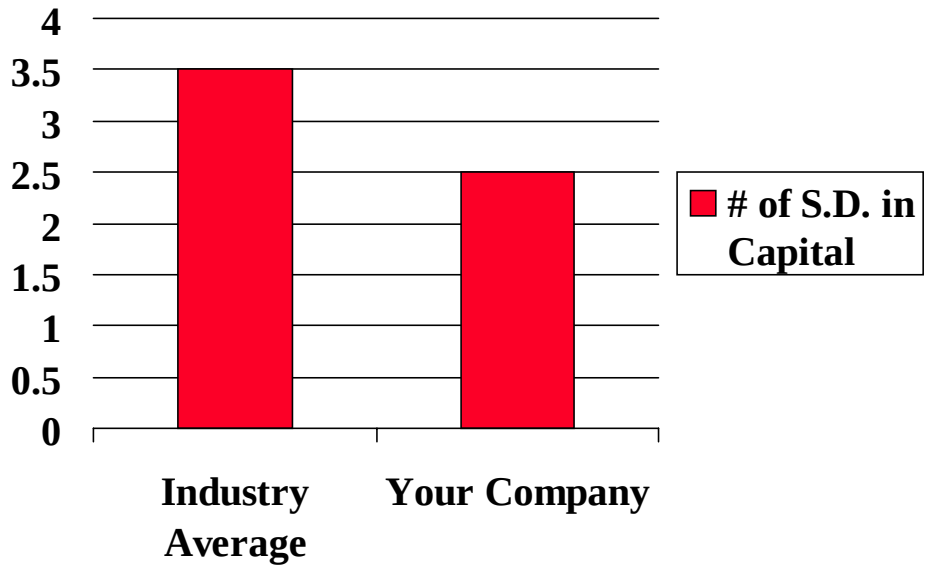
Current Earnings

$$\text{Market-to-Book} = \frac{\text{RAROC}}{\text{Req Return - Earnings Growth}}$$

Risk of Earnings **Future Earnings**

After applying the same VaR model to this company's peers, we discover that the average company in this industry has 3.5 standard deviations of capital.

How much capital is enough?



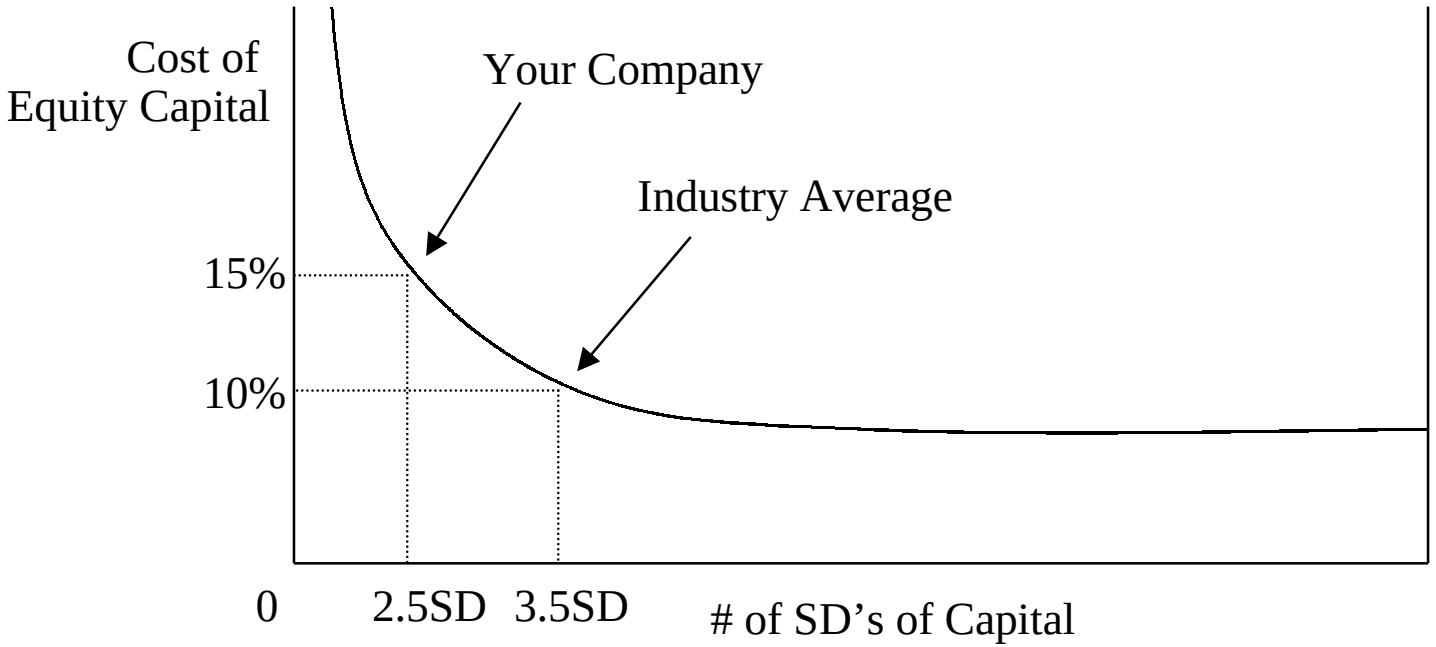
Is 2.5 standard deviations of capital enough for:

- An optimal capital structure?
- An 'A' rating?
- Maximizing EVA?
- Maximizing share price?

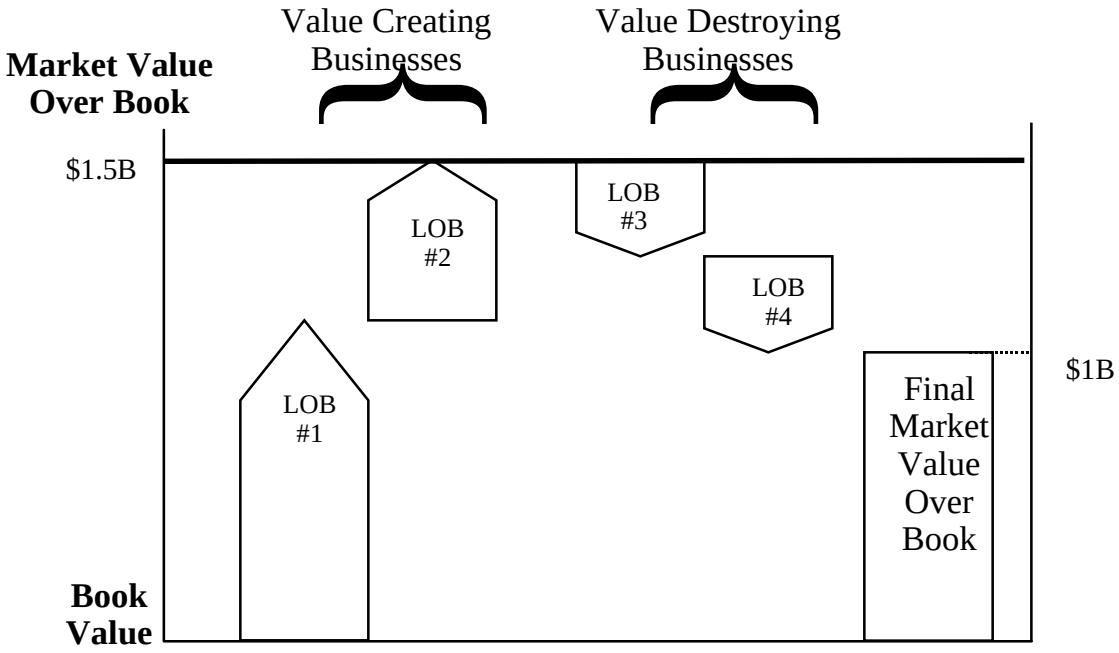
Financial theory provides a framework for estimating the impact of your company's undercapitalization on its cost of equity

Modigliani-Miller (MM) Theory

MM Theory states that the cost of equity capital is a function of leverage (Equity/Total Asset)



Seabury analysis reveals that for the average insurance company, 50% of its businesses create 150% of the value over book.



Redeploying capital from value destroying to value creating businesses can improve a company's market value significantly.

Table of Contents

Compare and Contrast BCAR and ERM

	BCAR	A.M. Best / Seabury GCM
Interest Rate Risk	• Estimated average asset duration * interest movement.	• Use asset duration minus liability duration • Estimate interest rate risk of each class of fixed income security based on historical market prices • Classify fixed income securities by region, by duration • Estimate diversification benefits among classes
Credit Risk	• Risk of reinsurers • Based on NAIC risk class	• Reinsurers' risk estimated based on their ratings • Credit risk of bond estimated with historical rating movements • Classify bond by region, by rating, and by sectors of issuers • Adjust for correlation among all risky bonds
Foreign Exchange Risk	• Not modelled	• Based on historical exchange rate volatility by region
Equity Risk	• Apply 30% as required capital	• Risk factors based on historical volatility of stock index by region
Insurance Risk	• Apply risk factors on premiums and reserves by lines.	• Apply risk factors on premiums and reserves by lines. • Risk factors estimated with historical underwriting results
Diversification Benefits	• Assume almost all risk categories have zero correlation with each others • Assume business risk has perfect correlation with the rest.	• Estimated the diversification benefits based on the historical correlation among each risk category

Value-at-Risk vs. Dynamic Financial Analysis

	Value-at-Risk	Dynamic Financial Analysis
Characteristics	• VaR calculates a company's risk exposure based on its exposure to risk factors. Risk factors are observed from market data. • VaR will project the downside risk as well as the risk to future net worth.	• DFA is a cash flow simulation model based on management assumptions and/or computer-generated economic scenarios that predict a company's future financial status. • DFA will project downside risk and a range of future financial results, including net income, surplus and invested assets.
Benefits	• VaR is objective because it is based on market data. VaR is not based on management projections of future operations. • VaR is easy to update, and it is suitable for frequent rerun and hypothesis testing. • VaR can facilitate many risk factors with ease. New risk factors can be easily added to a VaR model.	• DFA is good at capturing non-normal risk (such as CAT risk, lapse rate and non-proportional reinsurance) since it models the underlying distribution of the financial results.
Disadvantages	• If a company is dominated by a few non-normal risks (such as CAT risk), VaR is not optimal at estimating the resulting downside risk because it does not model the underlying distribution. However, statistical methods can be applied to facilitate all but a few of these cases. See page 63, i.e., "Adjusting AM Best's ERM to accommodate non-normal risks," for an elaboration of these technizues.	• DFA outcomes are based on management's subjective projections of revenue and earnings growth. • DFA models are very customized, therefore it is very hard for outsiders to assess their accuracy. • Creating, operating and maintaining a DFA capability is costly and time consuming. As a result, DFA is not an optimal tool for frequent hypothesis testing unless a company has dedicated staff to support the process. • DFA typically captures fewer risk factors than VaR, due to the difficulty of tracking large numbers of risk factors in a DFA model.

The Credit Volatility

Given the possible future values of a bond and their respective probability, we can calculate the volatility using the following formula:

$$\sigma^2 = \sum_{i=1}^{k} p_i \times (V_i - \overline{V})^2$$

σ^2 : volatility

p_i : probability of event i

V_i : bond value at event i

$\overline{V}$: average bond value

Capital Allocation for CAT Risk

Adding a CAT risk liability to a non-CAT liability portfolio will have more impact on the default probability than on earnings volatility. Adding CAT risk can increase default probability without adding earnings volatility.