



# Best Practices in Risk Management

**Track 1:** Monday, May 20th  
INFORMS Conference on  
OR/MS Practice  
Analytic Methods in Practice  
10:30 am - 11:20 am

Analyzing & Enhancing The  
Extended Enterprise  
Hilton Montreal Bonaventure  
Montreal, Canada

**Dr. Robert M. Mark**  
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Black Diamond Risk Enterprises  
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### **ABOUT DR. ROBERT MARK**

**Dr. Robert M. Mark** is the President & Chief Executive Officer of Black Diamond. Black Diamond provides financial service consulting and risk transaction services. He serves on the Boards of the Fields Institute for Research in Mathematical Sciences, IBM's Deep Computing Institute and the Royal Conservatory. In 1998 he was awarded the Financial Risk Manager of the Year award by the Global Association of Risk Professionals (GARP).

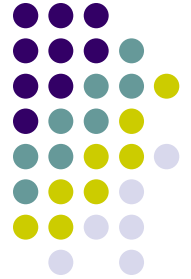
Prior to his current position he was the Senior Executive Vice President and Chief Risk Officer (CRO) at the Canadian Imperial Bank of Commerce (CIBC). Dr. Mark reported directly to the Chairman and Chief Executive Officer of CIBC, and was a member of the Management Committee. Dr. Mark's global responsibility covered all credit, market and operating risks for all of CIBC as well as for its subsidiaries. Prior to his CRO position, he was the Corporate Treasurer at CIBC.

Prior to CIBC, he was the Partner in charge of the Financial Risk Management Consulting at Coopers & Lybrand (C&L) within the financial services practice. The Risk Management Practice at C&L advised clients on market and credit risk management issues and was directed toward financial institutions and multi-national corporations. This specialty area also coordinated the delivery of the firm's accounting, tax, control, and litigation services to provide clients with integrated and comprehensive risk management solutions and opportunities.

Prior to his position at C&L, he was a Managing Director in the Asia, Europe, and Capital Markets Group (AECM) at Chemical Bank. His responsibilities within AECM encompassed risk management, asset/liability management, research (quantitative analysis), strategic planning and analytic systems. He served on the Senior Credit Committee of the Bank. Before he joined Chemical Bank, he was a senior officer at Marine Midland Bank/Hong Kong Shanghai Bank Group (HKSB) where he headed the technical analysis trading group within the Capital Markets Sector.

He earned his Ph.D., with a dissertation in options pricing, from New York University's Graduate School of Engineering and Science, graduating first in his class. Subsequently, he received an Advanced Professional Certificate (APC) in accounting from NYU's Stern Graduate School of Business, and is a graduate of the Harvard Business School Advanced Management Program. He is an Adjunct Professor and co-author of "Risk Management" (McGraw-Hill), published in October 2000. He served on the board of ISDA and was also the Chairperson of the National Asset/Liability Management Association (NALMA).

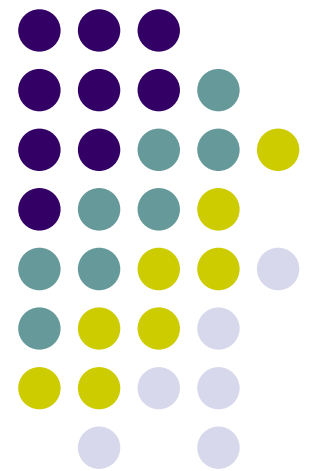
# Agenda



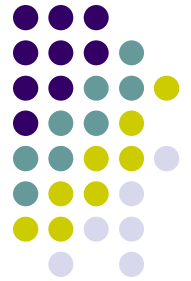
- A. Introduction
- B. Framework for Best Practice Risk Management
- C. Measurement of Market Risk
- D. Measurement of Credit Risk
- E. Risk Based Customer Value Management
- F. Transforming Risk into Value

# A

## Introduction\*



\* For more details, see “Risk Management” by Crouhy, Galai and Mark



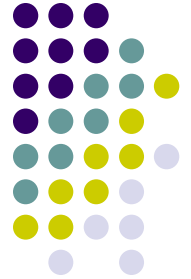
# Introduction

***Global trends are leading to ...***

- The rising importance of risk management In financial institutions
- More complex markets
  - Global markets
  - Greater product Complexity
  - Increasing competition
  - New players
  - Regulatory imbalances

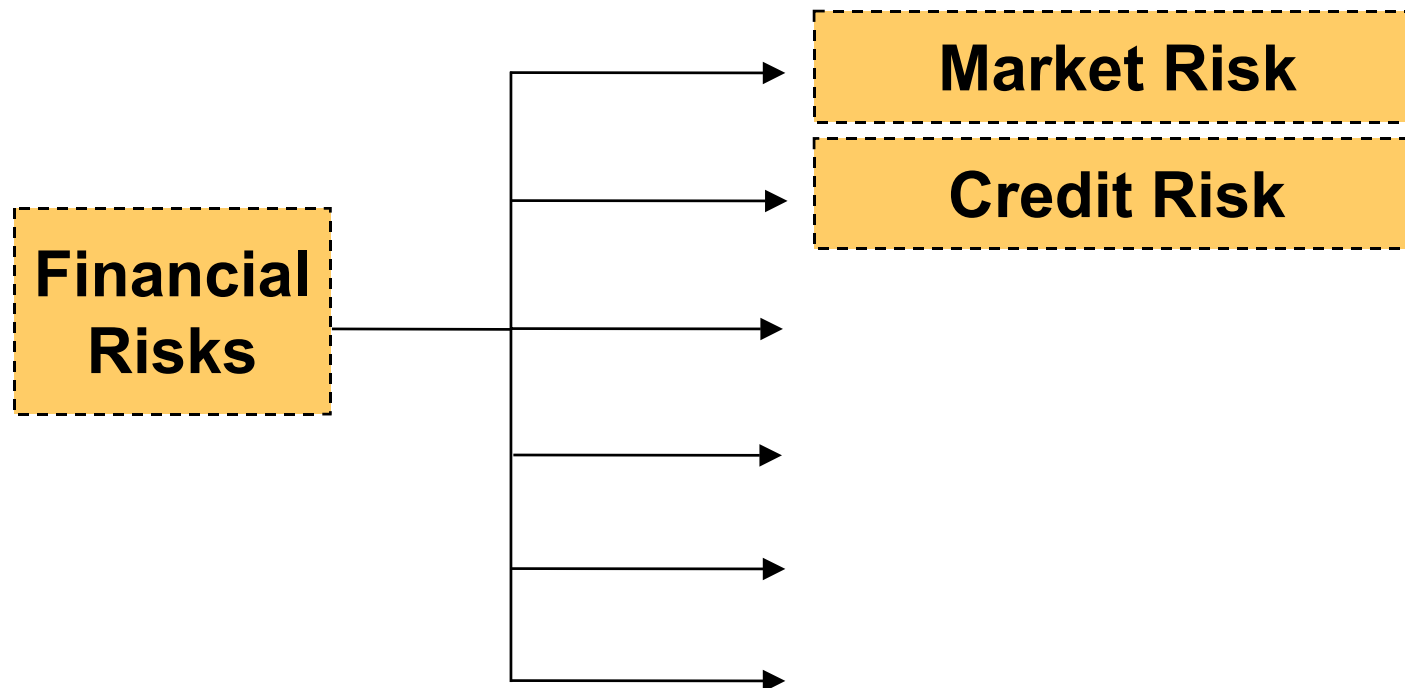


**Increased  
Risk**



# Introduction

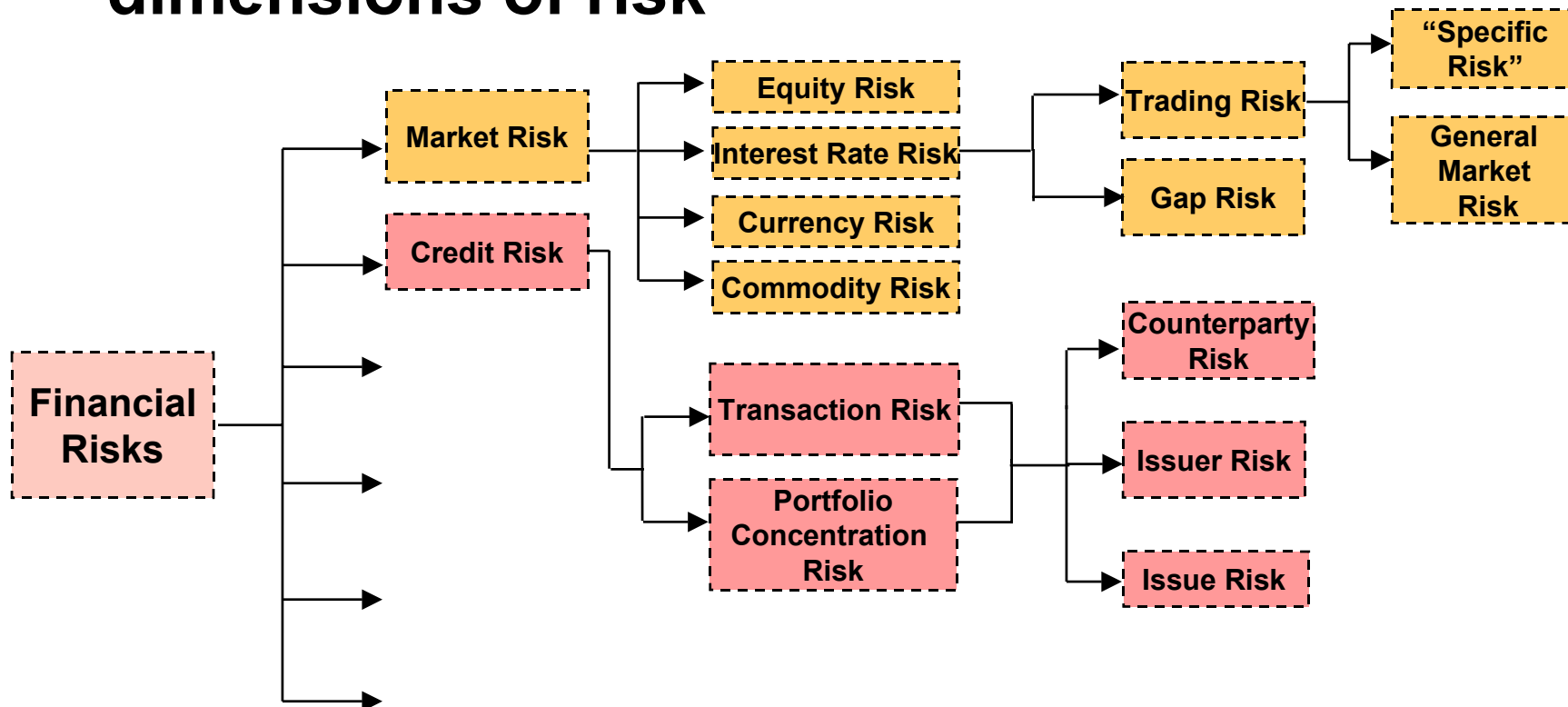
- Risk is Multidimensional





# Introduction

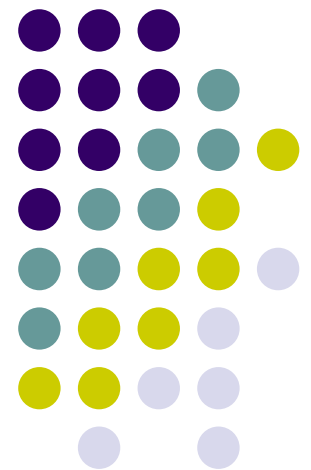
- One can “slice and dice” these multiple dimensions of risk\*



B

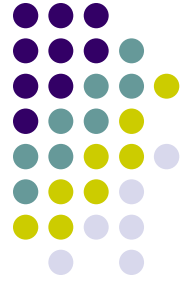
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# Framework for Best Practice Risk Management\*



\* For more details, see "Risk Management" by Crouhy, Galai and Mark

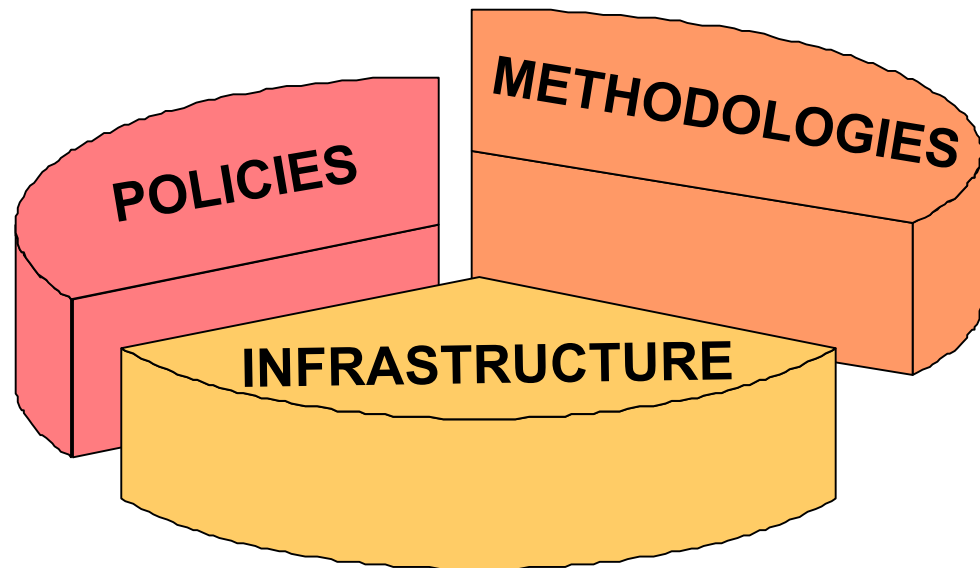


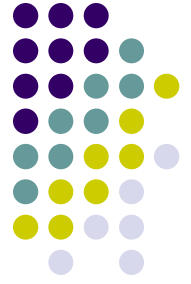


# Framework

- Framework for Risk Management can be benchmarked in terms of:

- Policies
- Methodologies
- Infrastructure





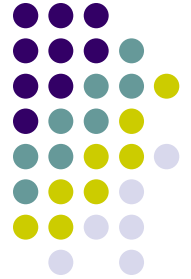
# Framework

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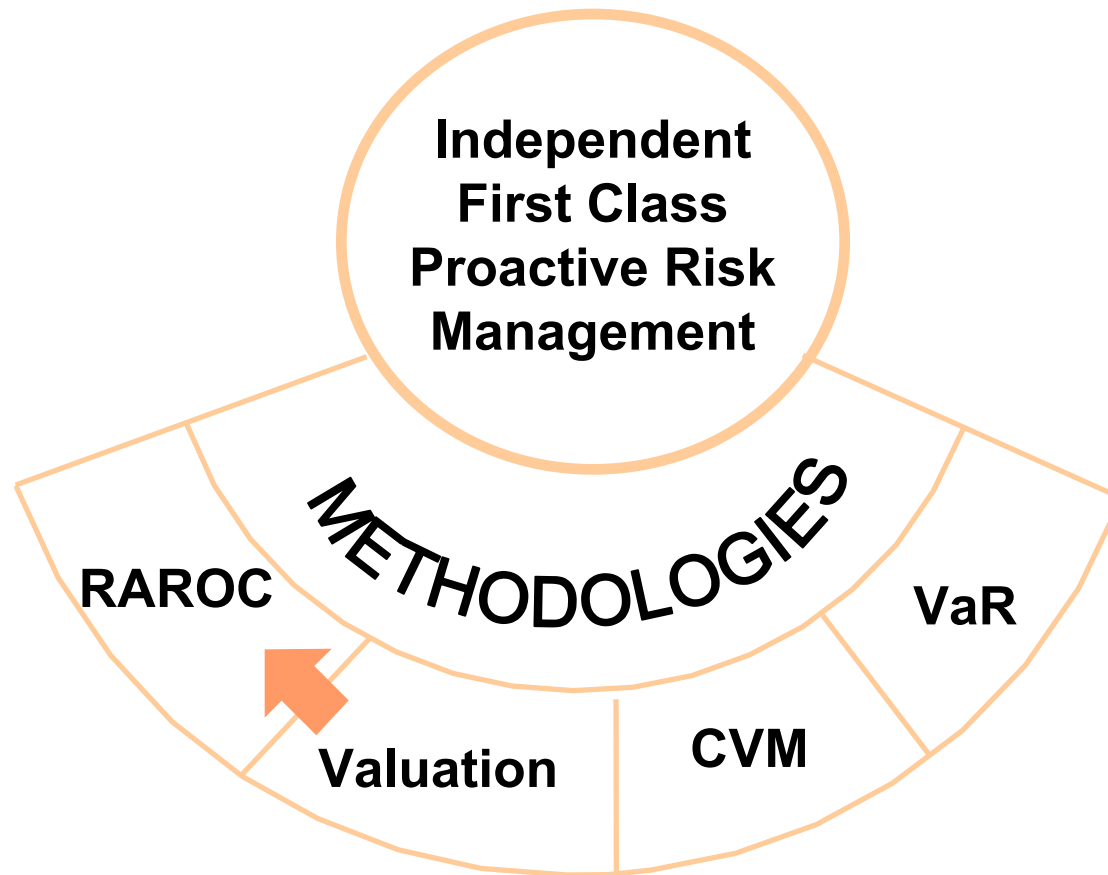
- **Policies**
- **Methodologies**
- **Infrastructure**



# Framework - Policies



# Framework - Methodologies



# Framework - Methodologies



## Quantification of Risk

- Value at Risk (VaR)  
(at a desired confidence level)
  - Transaction risk
  - Portfolio risk (capture correlation effect)
- Event Risk
  - Reasonable Paranoia
  - Scenario Testing  
(e.g. volatility and correlation slippage)

# Framework - Methodologies



- Value-At-Risk Framework

Construct families of functions  $f$  such that:

$$\text{Market Risk} = f \left( \begin{array}{l} \blacklozenge \text{ Volatilities} \\ \blacklozenge \text{ Correlations} \\ \blacklozenge \text{ Liquidity Period} \\ \blacklozenge \text{ Market Value} \\ \blacklozenge \text{ Etc.} \end{array} \right)$$

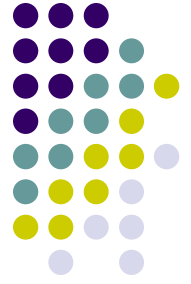
# Framework - Methodologies



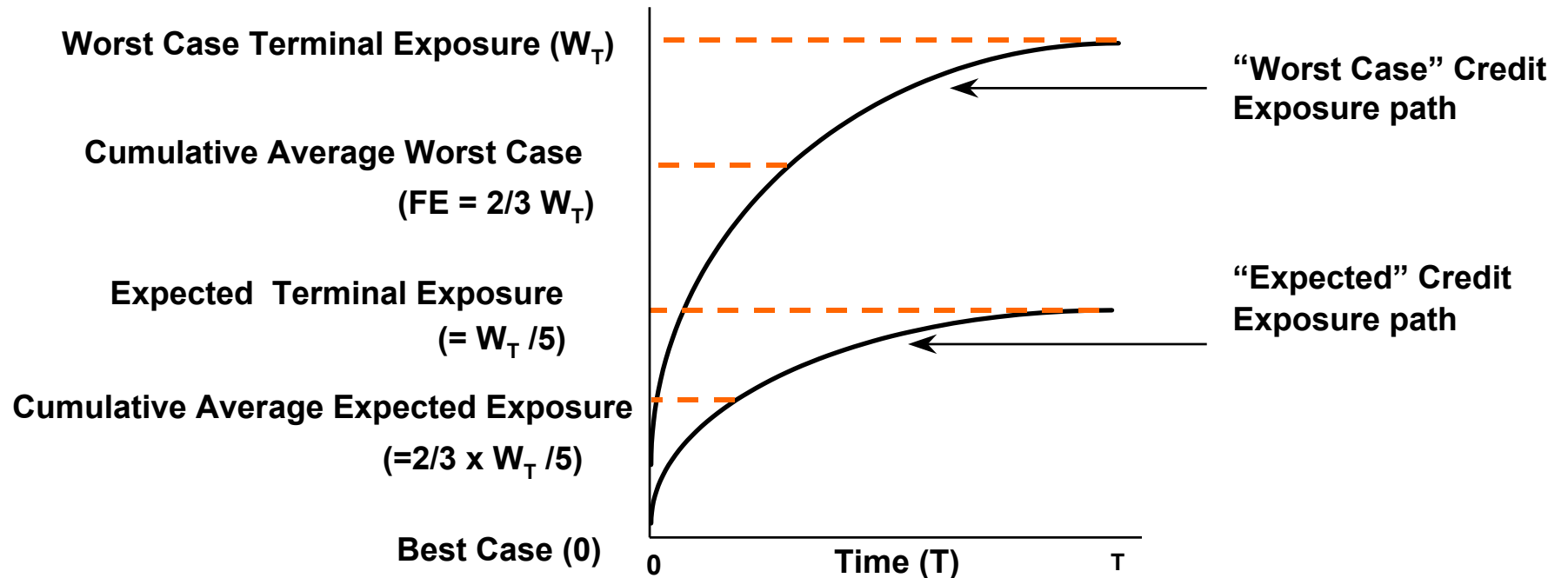
- Credit losses are estimated through analyses of the future distributions of risk factors

$$\text{Credit Losses} = f \left( \begin{array}{l} \diamond \text{ Future Market Value} \\ \text{Exposure Distributions} \\ \diamond \text{ Default Rate} \\ \text{Distributions} \\ \diamond \text{ Recovery Rate} \\ \text{Distributions} \end{array} \right)$$

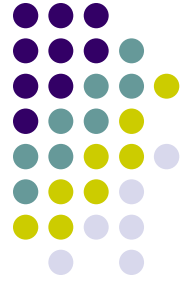
# Framework - Methodologies



- Example: Credit exposure profile for single cash flow products



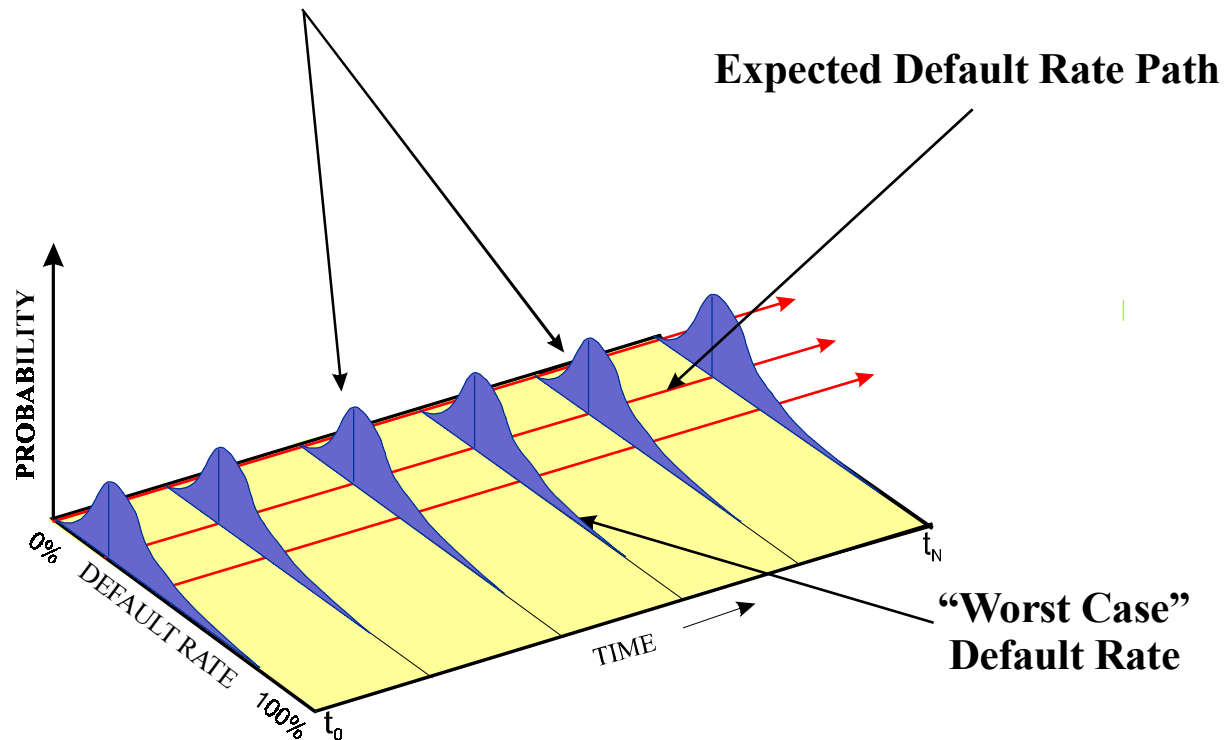




# Framework - Methodologies

- Default Rate Distribution

Distribution of Future Default Rates

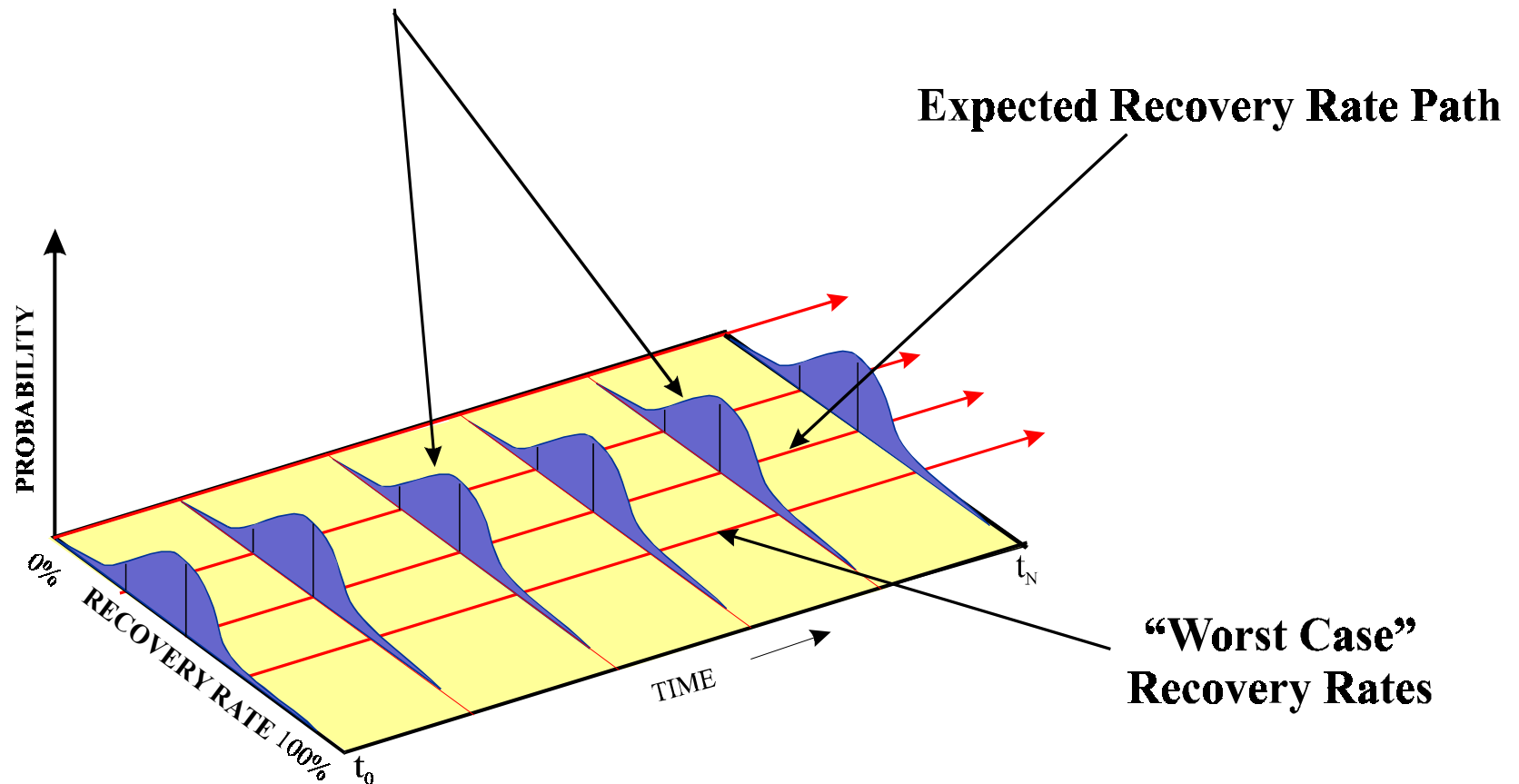


# Framework - Methodologies

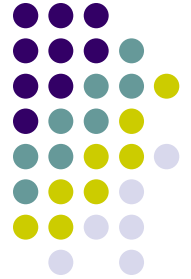


- Recovery Rate Distribution

## Distributions of Future Recovery Rates



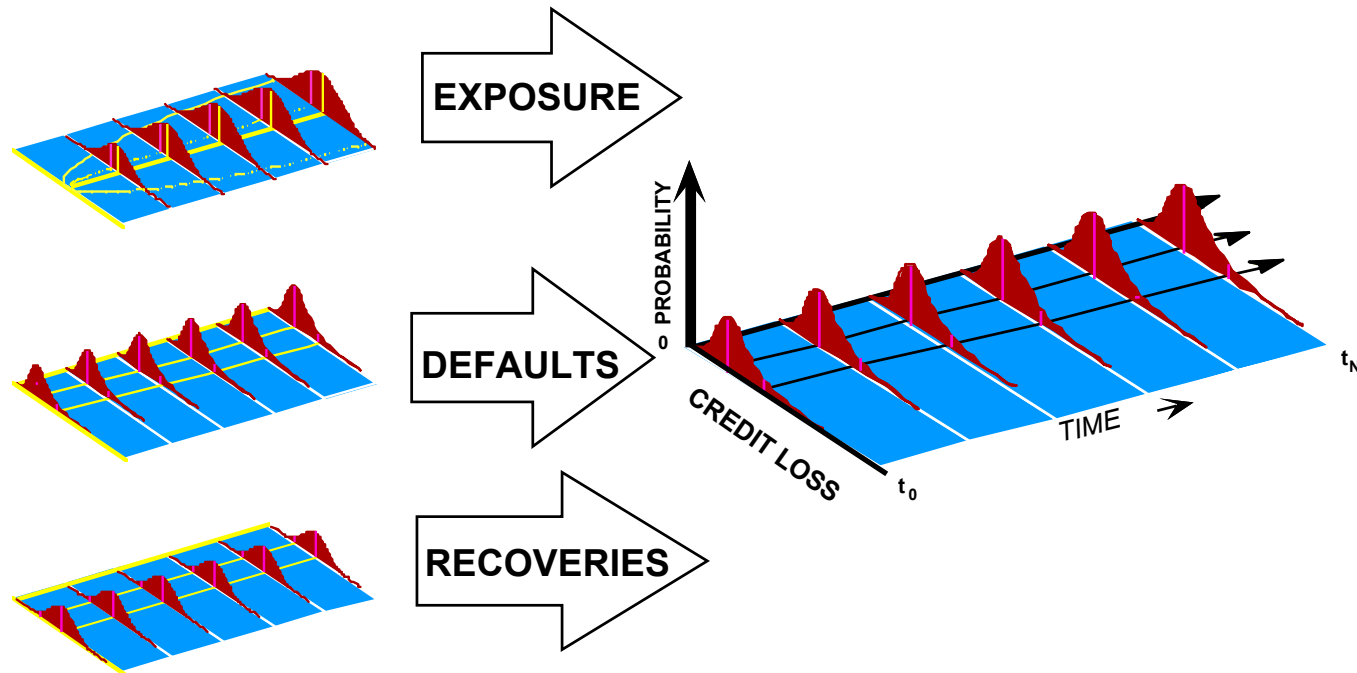
# Methodologies



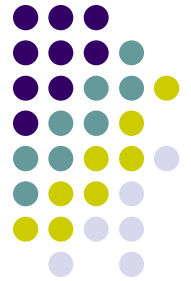
- Credit Risk

- Distributions of credit risk factors may be combined to produce future credit loss distributions

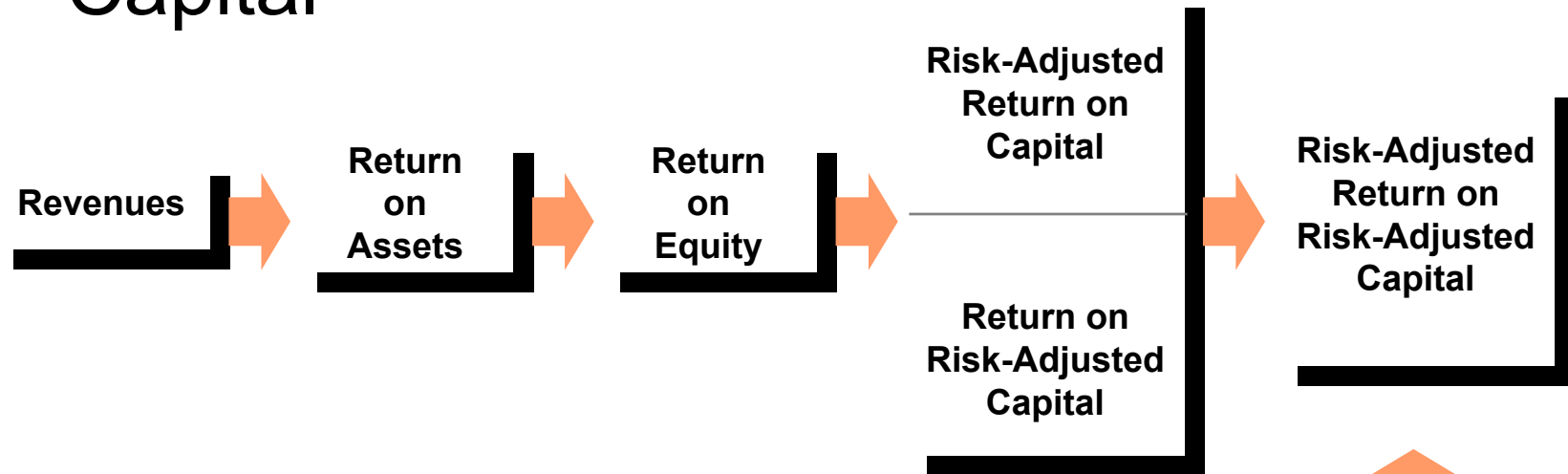
## EXAMPLE



# Framework - Methodologies



- Risk Adjusted Return on Risk Adjusted Capital



## Evolution of Performance Measures



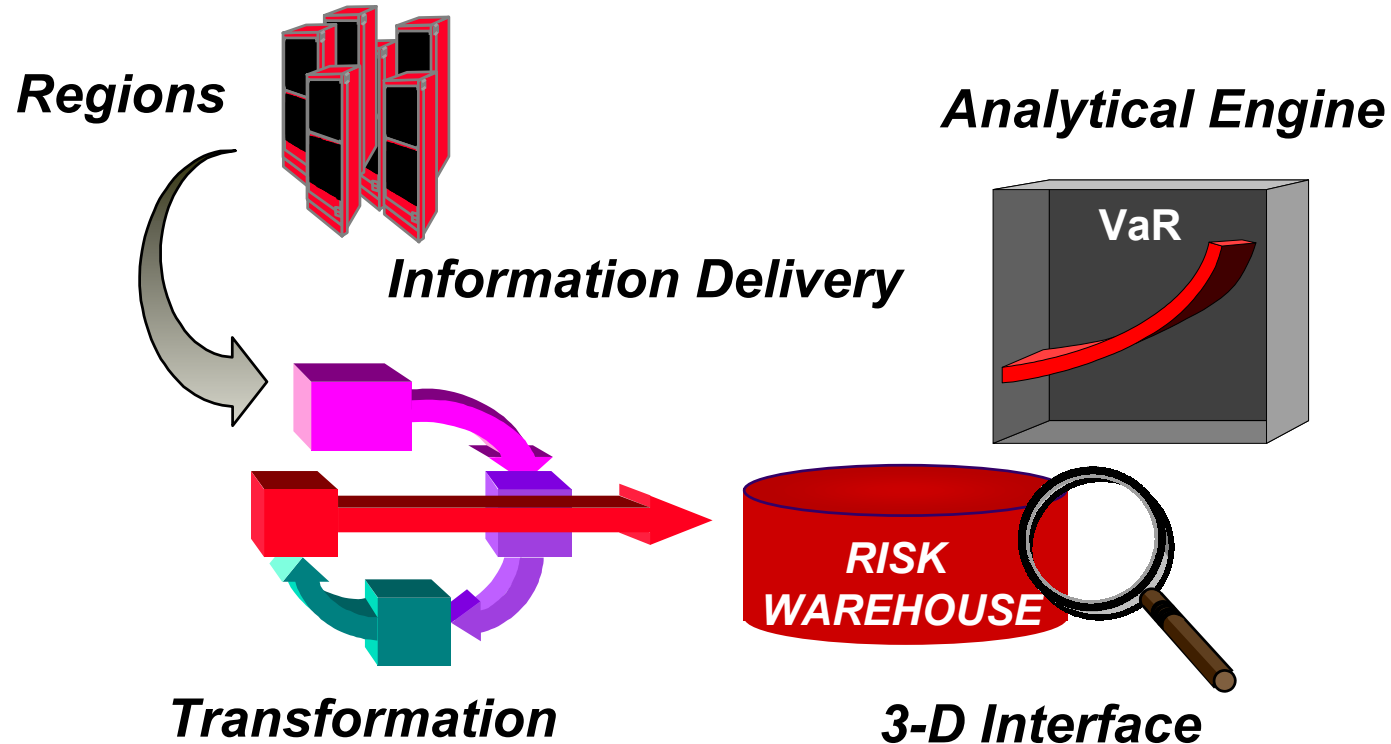
# Framework - Infrastructure



# Framework - Infrastructure

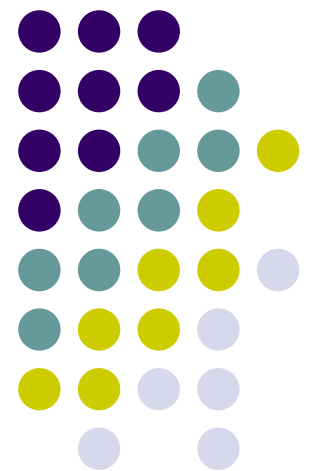


- Risk MIS

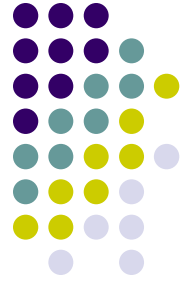


C.

# Measurement of Market Risk\*

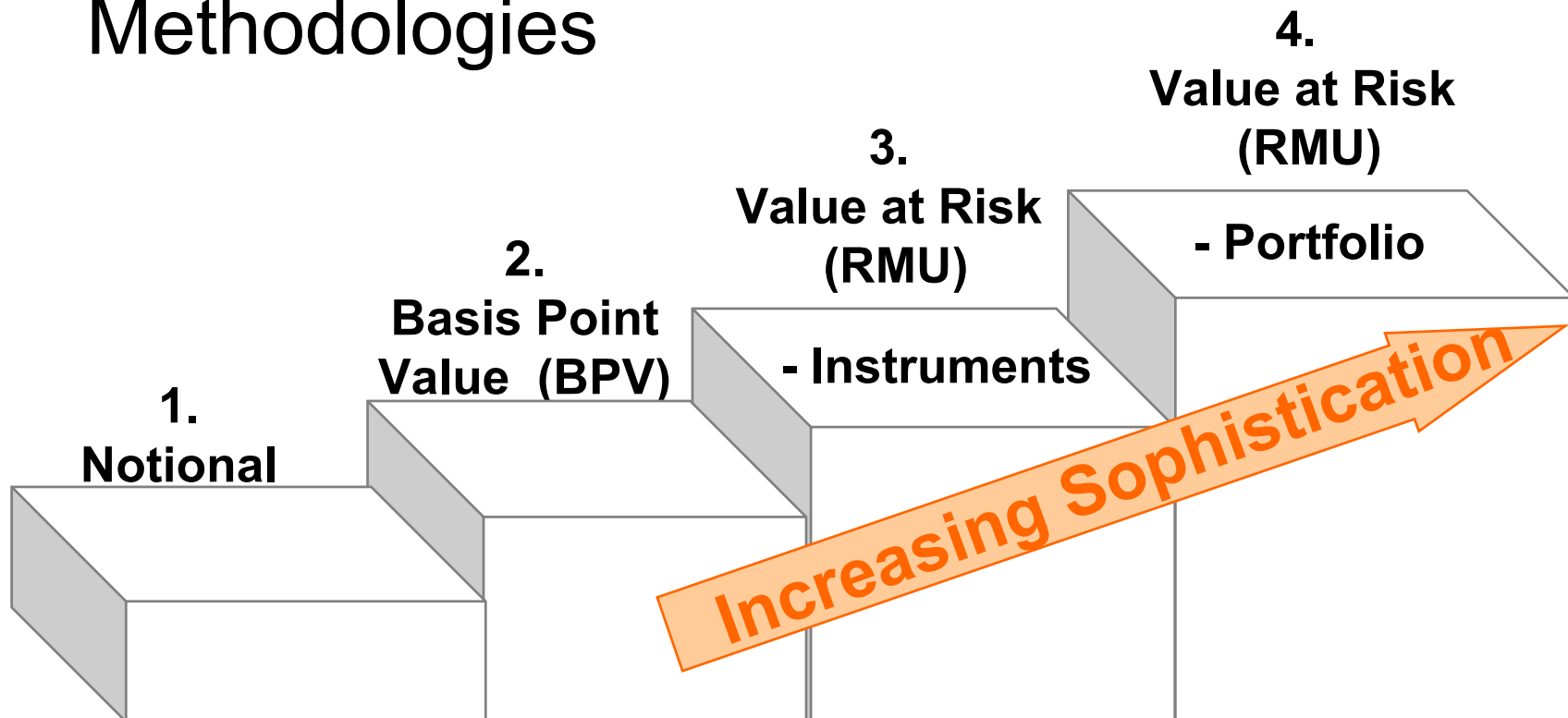


\* For more details, see “Risk Management” by Crouhy, Galai and Mark



# Measuring Market Risk

- Market Risk Measurement Methodologies



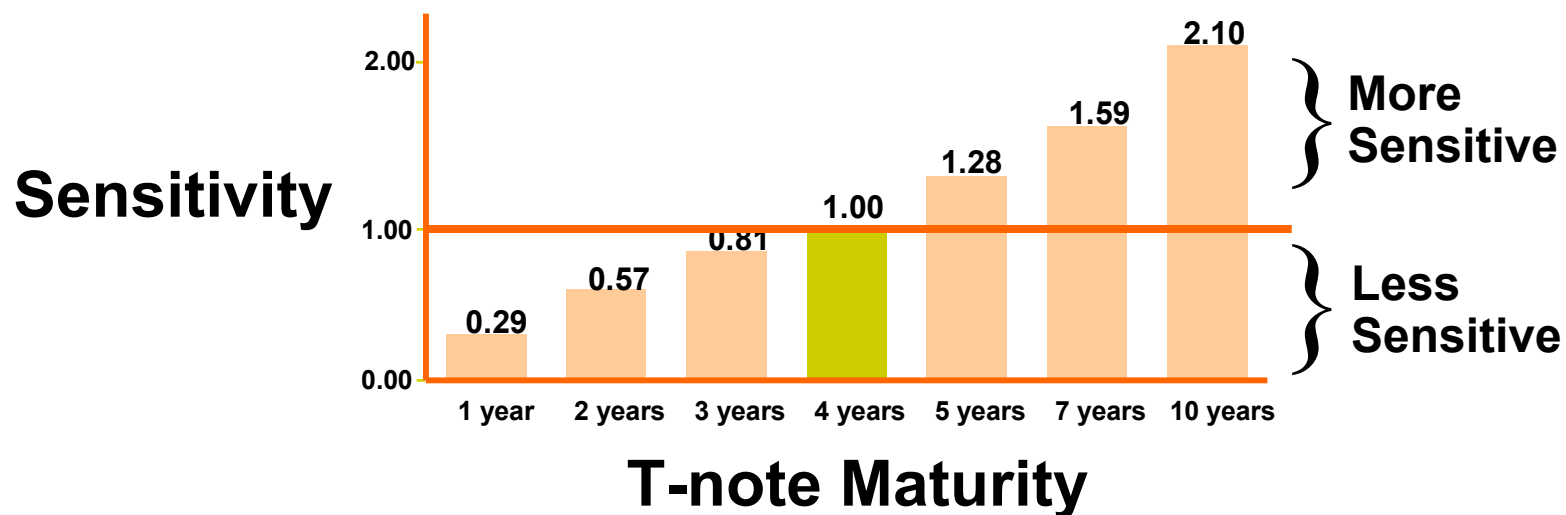




# Measuring Market Risk

- Sensitivity of T-Note Relative to Benchmark

## EXAMPLE



2.1 million 4-year T-note → Risk Equivalent ← 1 million 10-year T-note



# Measuring Market Risk

- 3. Mini-RMU: The Extended Basis Point Value Approach

Instrument (T-Note)	One Basis Point Value	“Worst Case” Movement (bp)		Total Value at Risk	RMUs
1 year	91	*	12	1,092	1.1
2 year	177		11	1,947	1.9
3 year	252		10	2,520	2.5
4 year	312		10	3,120	3.1
5 year	400		9	3,600	3.6
7 year	496		9	4,464	4.5
10 year	654		8	5,232	5.2

**2.33 $\sigma$  offers 99% coverage = “Worst Case” movement**



# Measuring Market Risk

## RMU Example

Action	Market Value	Worst Case Risk (RMU)
Long A	100	2
Short B	100	2



# Measuring Market Risk

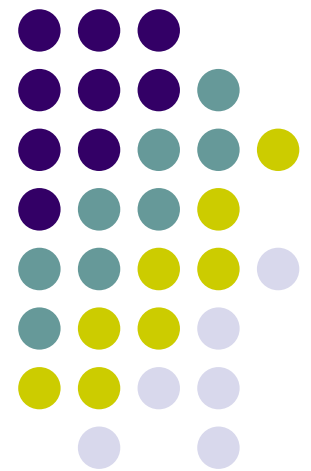
## RMU Example

CASE	MARKET VALUE		COMMENT	VALUE AT RISK (RMU)
I	A \$98 ↓	B \$102 ↑	Perfect Negative Correlation (-1.0)	4
II	\$101 ± ↑	\$103 ± ↑	Some Correlation (.50)	2
III	\$102 ↑	\$102 ↑	Perfect Positive Correlation (+1.0)	0
IV	\$98 ↓	?	No Correlation (0)	2.8

Note:  $RMU = \sqrt{RMU_A^2 + RMU_B^2 - 2 \times \rho_{AB} \times RMU_A \times RMU_B}$

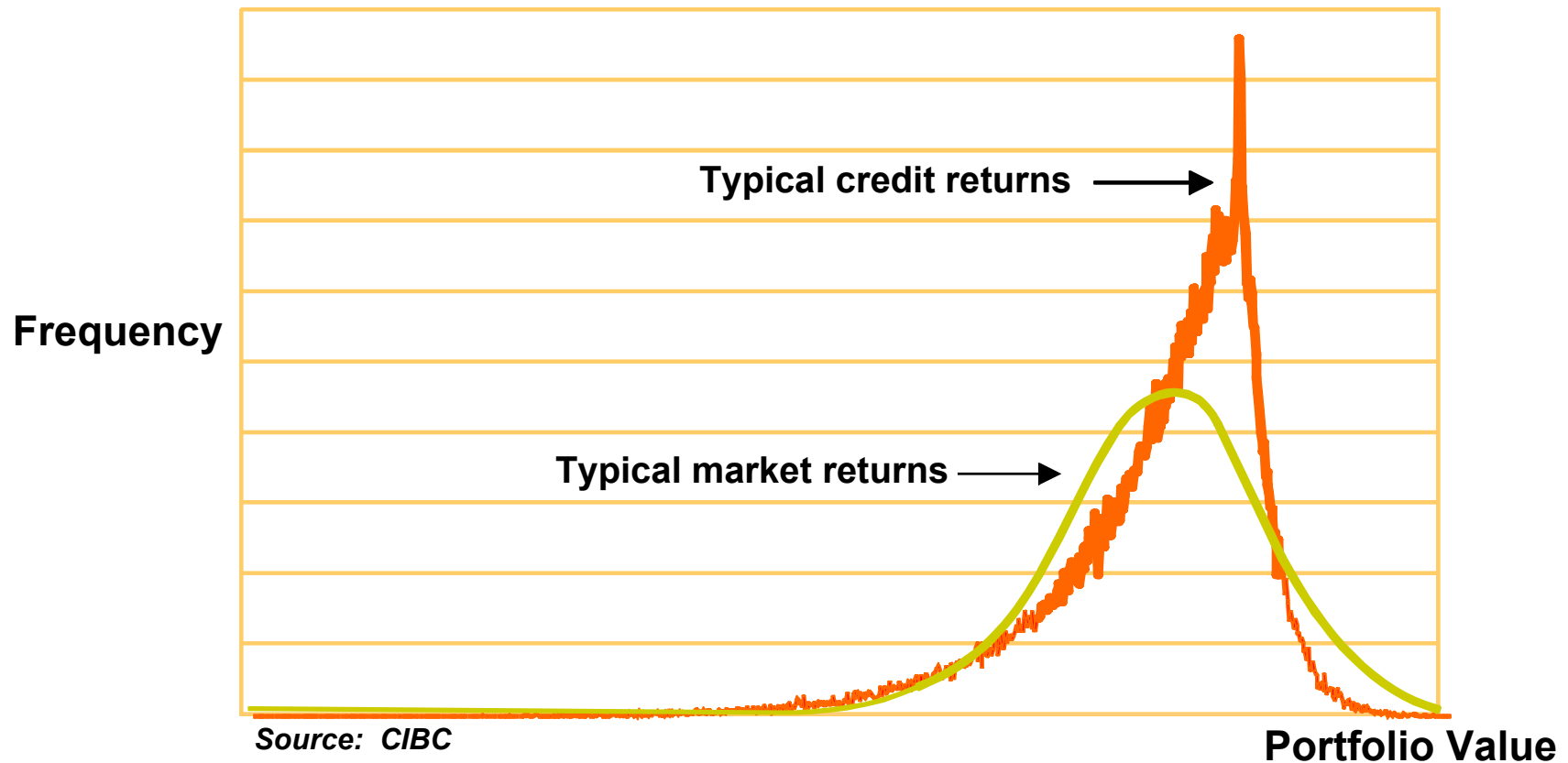
D.

# Measurement of Credit Risk\*

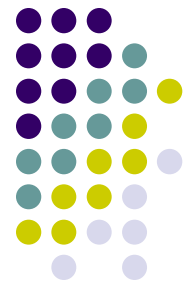


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# Measuring Credit Risk: Overview



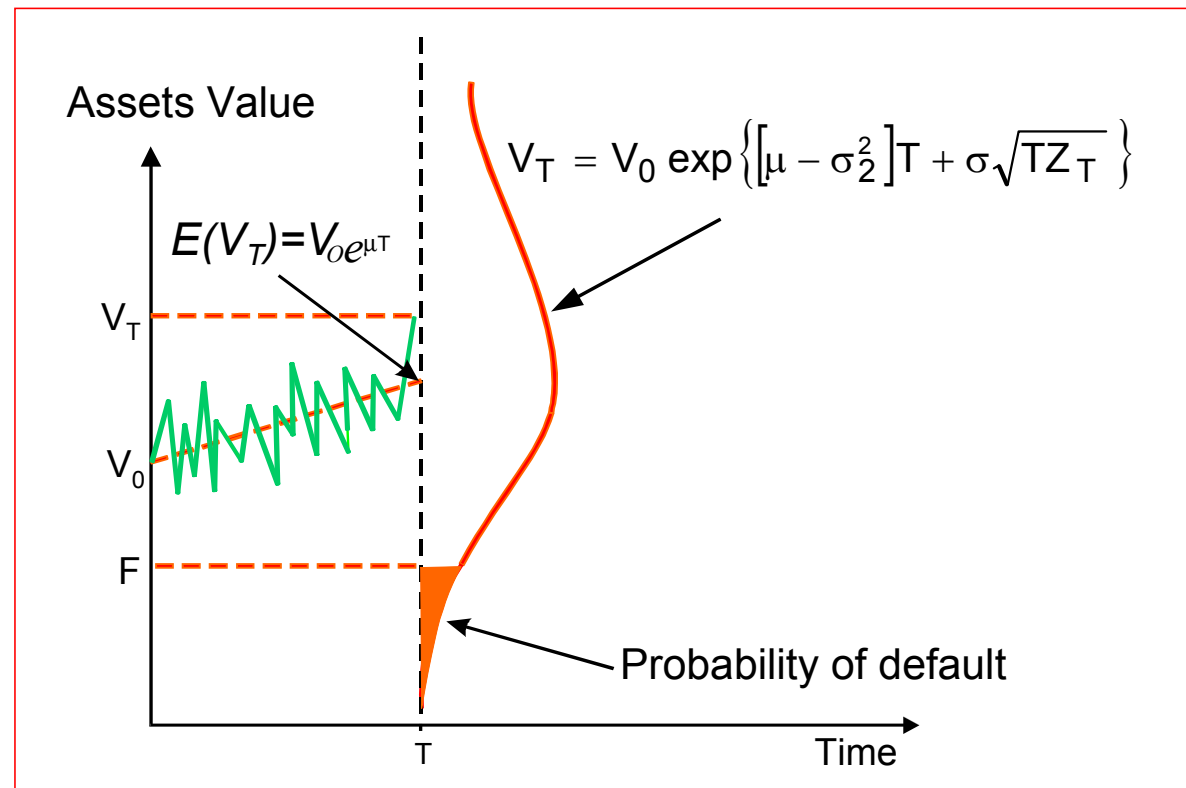
Comparison of the distributions of credit returns and market returns.

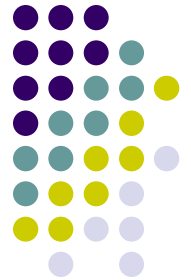


# Merton's model

## Probability of default

**Distribution  
of asset  
values at  
maturity of  
the debt  
obligation**





# Merton's Model

**Based on the option pricing approach to credit risk as originated by Merton (1974)**

**The firm's asset value,  $V_t$ , follows a standard geometric Brownian motion, i.e.:**

$$V_t = V_0 \exp \left\{ \left( \mu - \frac{\sigma^2}{2} \right) t + \sigma \sqrt{t} Z_t \right\}$$





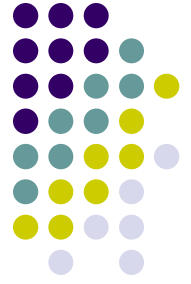
# Merton's Model

**Bank's pay-off matrix at times 0 and T for making a loan to Firm CGM and buying a put on the value of CGM**

Time	0	T	
Value of Assets	$V_0$	$V_T \leq F$	$V_T > F$
<b>Bank's Position:</b>			
• make a loan	$-B_0$	$V_T$	$F$
• buy a put	$-P_0$	$F - V_T$	$0$
<b>Total</b>	$-B_0 - P_0$	$F$	$F$

Source: Crouhy, Galai, Mark (1997)  $B_0 + P_0 = Fe^{-rT}$

**Corporate loan = Treasury bond + short a put**



# Merton's Model

- **Firm CGM is structured as follows:**

**$V_t$  = Value of Assets (at time t)**

**$S_t$  = Value of Equity**

**$B_t$  = Value of Debt (zero-coupon)**

**F = Face Value of Debt**

$$1 \quad P_o = f ( V_o, F, \sigma_y, r, T )$$

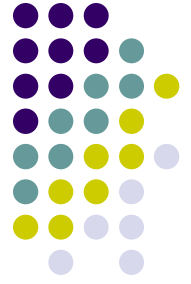
$$2 \quad \mathbf{B}_o = \mathbf{F} \mathbf{e}^{-\mathbf{rT}} - \mathbf{P}_o$$

3  $S_o = V_o - B_o$  (assuming frictionless  
3 markets)

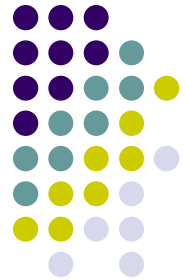
4  $B_0 = Fe^{-Y_T}$  where  $Y_T$  is yield to maturity

**5 Probability of Default =  $g(V_0, F, \sigma_v, r, T) = N(-d_2)$**

## 6 Conditional recovery when default = $V_T$



# KMV: Merton's model



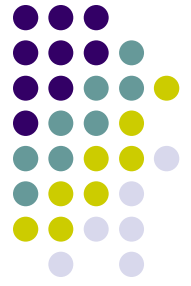
**Default spread for corporate debt  
( For  $V_0 = 100$ ,  $T = 1$ , and  $r = 10\%$  )**

LR \ $\sigma$	0.05	0.10	0.20	0.40
0.5	0	0	0	1.0
0.6	0	0	0.1%	2.5%
0.7	0	0	0.4%	5.6%
0.8	0	0.1%	1.5%	8.4%
0.9	0.1%	0.8%	4.1%	12.5%
1.0	2.1%	3.1%	8.3%	17.3%

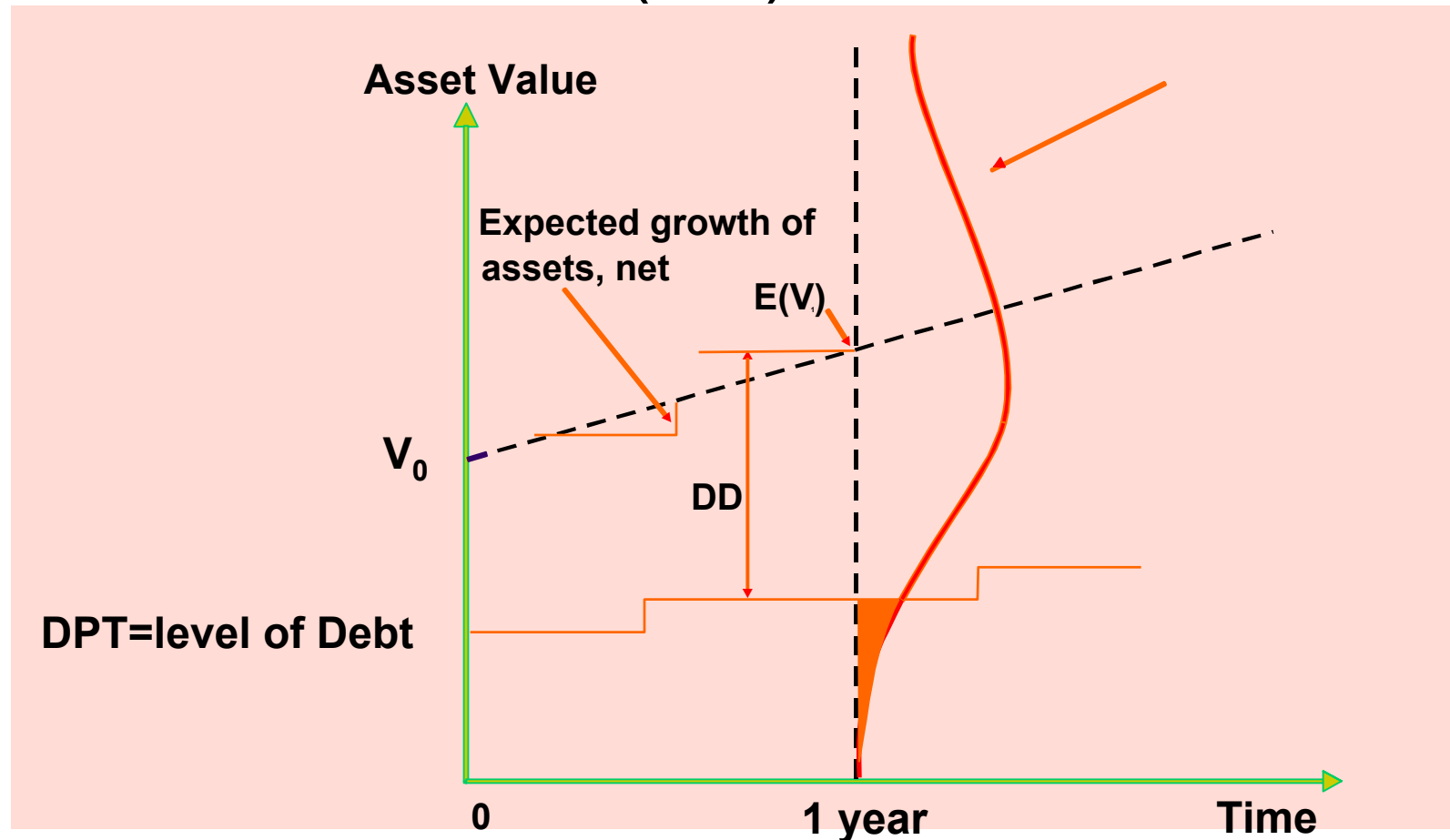
Source: Crouhy, Galai, Mark (1997)

Note:  $LR \left( \equiv \frac{Fe^{-rT}}{V_0} \right)$

# KMV: A Commercial Model Provides EDF's



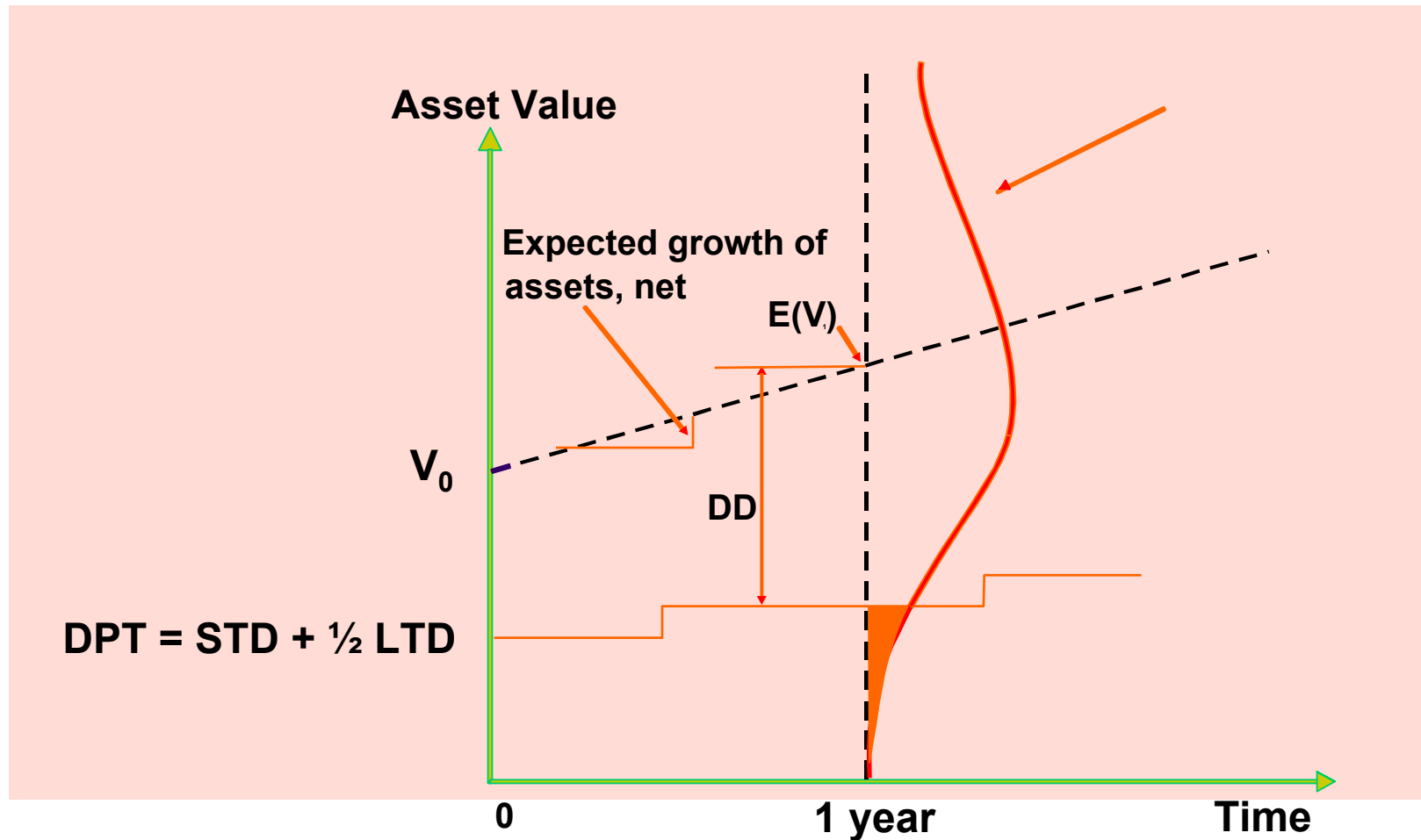
- Distant to default (DD)



# KMV: EDFs



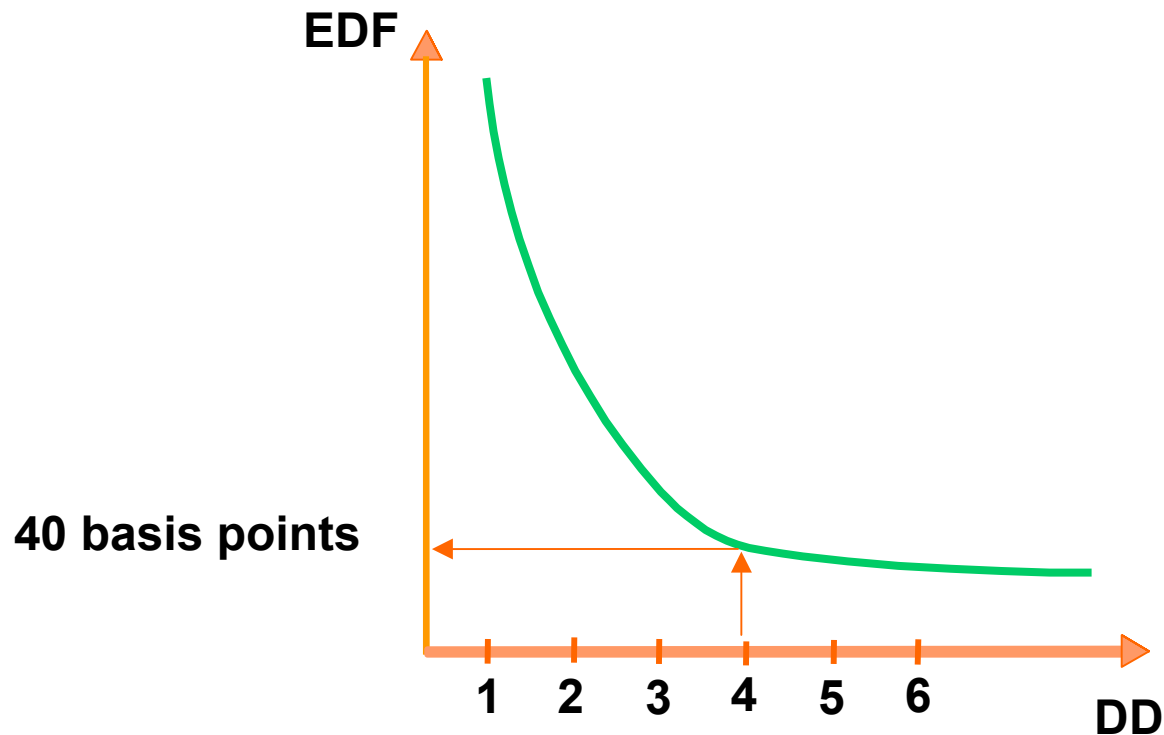
- Distant to default (DD)



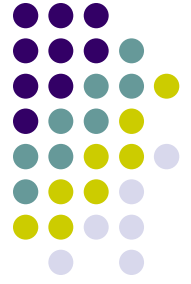
# KMV: EDFs



- Derivation of the probabilities of default from the distance to default

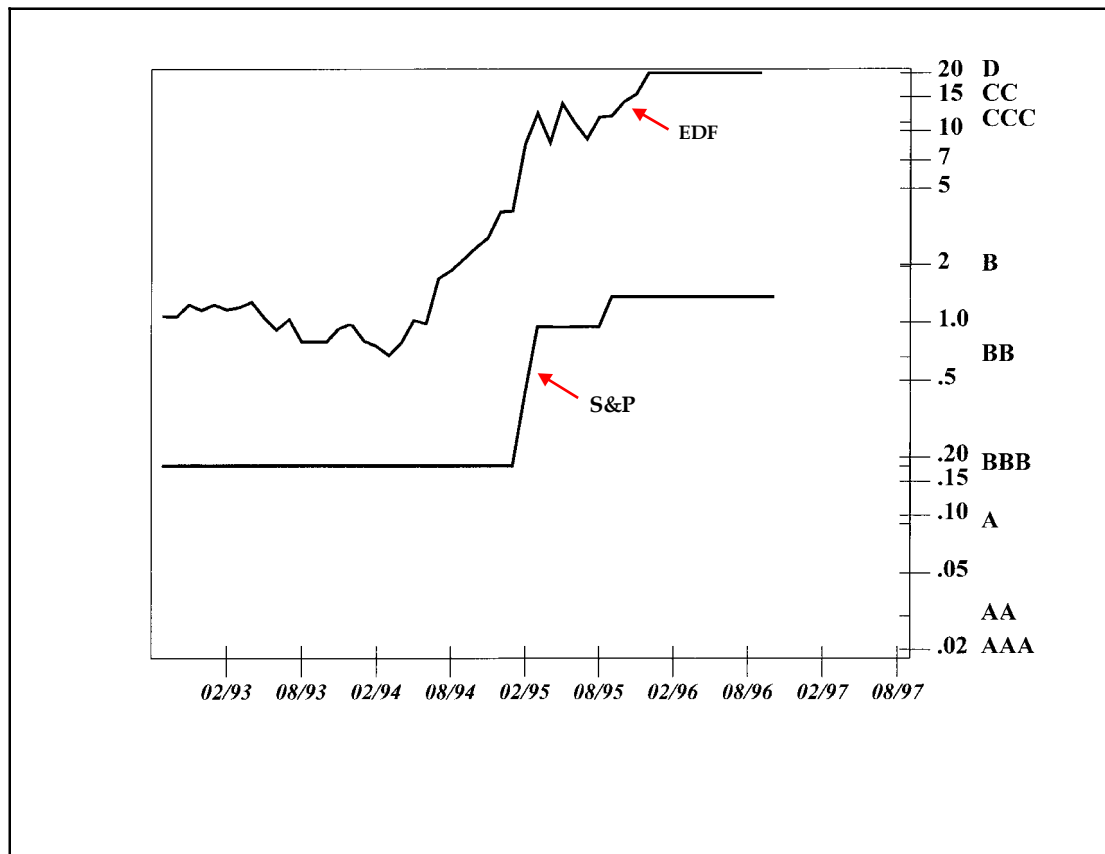


# KMV: EDFs



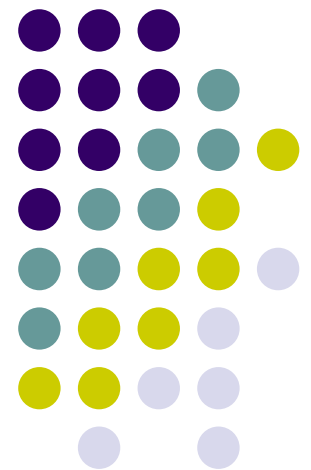
- EDF as a predictor of default

**EDF of a firm which actually defaulted versus Standard & Poor's rating.**



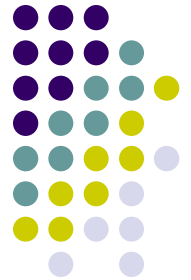
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# Risk Based Customer Value Management\*



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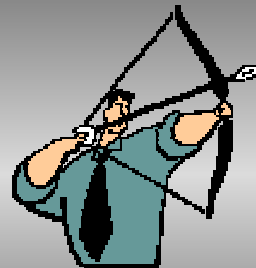




**X-Profiler**



**X-Tractor**



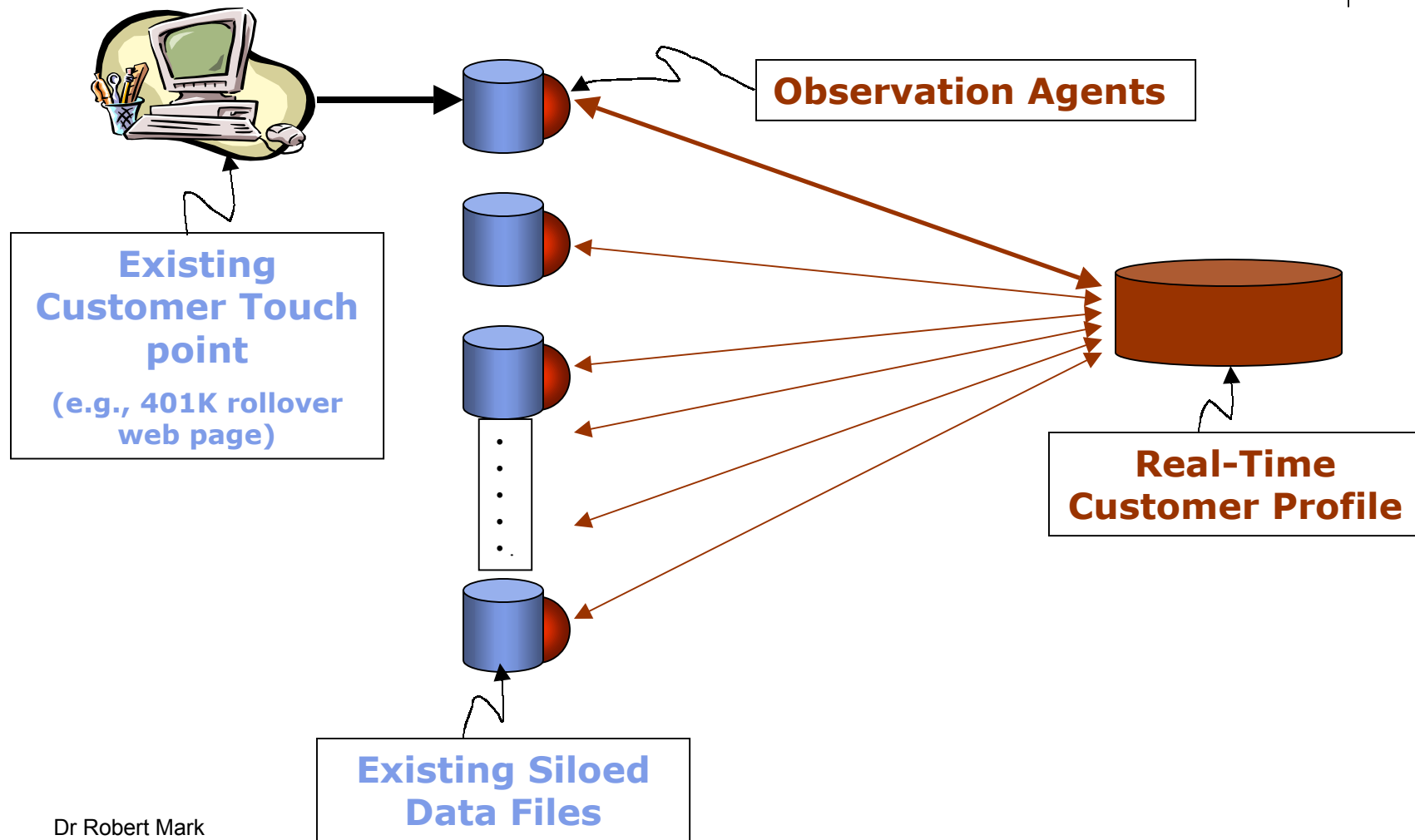
**X-Seller**

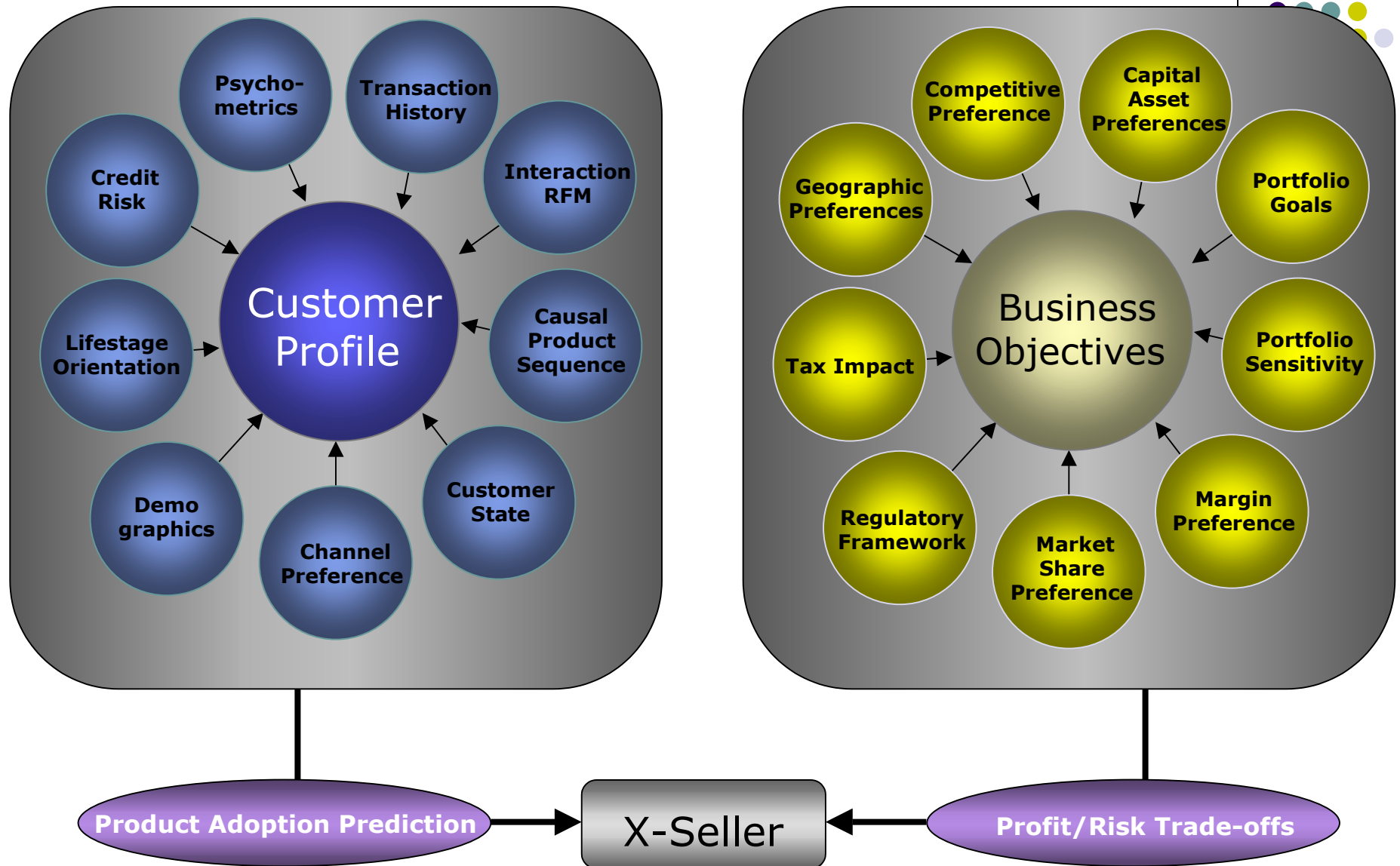
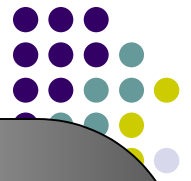


**Systems Administration**

Example: Xamplify



Observation Agents provide real-time un-intrusive updates on individual and aggregate customer characteristics using key touch points.





Psychometric Profiles, combined with demographic and transaction data, allow you to predict responses more accurately.

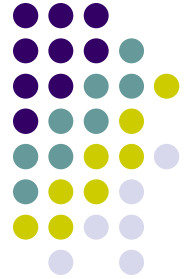


		
Demographics		
Transactions		
Psychometrics	<ul style="list-style-type: none"> <li>• High optimism bias</li> <li>• Not interested in news</li> <li>• Convenience/status-oriented</li> <li>• Agreeable/Open</li> <li>• Relational</li> </ul>	<ul style="list-style-type: none"> <li>• Low regret aversion</li> <li>• Highly interested in news</li> <li>• Price-sensitive</li> <li>• Opinionated/Suspicious</li> <li>• Independent/self-sufficient</li> </ul>

Good candidate  
for newer actively-  
managed  
investments  
offered by  
telemarketing

Good candidate for  
established self-  
directed investments  
offered in print

# Risk Based Customer Value Management (RBCVM)



RBCVM is based on an observe, predict and decide approach

Adaptive decision strategies are dynamic

= RBCVM

INCREASING KNOWLEDGE REQUIRED

+ Apply Adaptive Strategies

+ Perform Risk Analysis & Allocate Economic Capital

+ Stress Testing & Scenario Analysis

+ Psychometric Analysis

Perform Predictive Analysis

+ Real Time

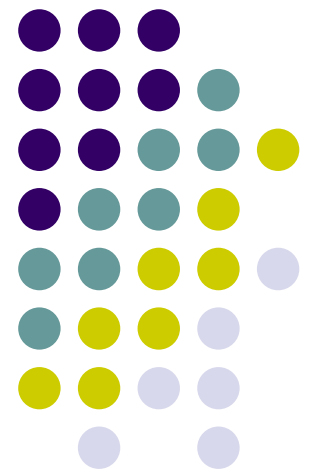
Un-Intrusive

Collect, Observe & Organize Data

Best Practice CRBVM Management

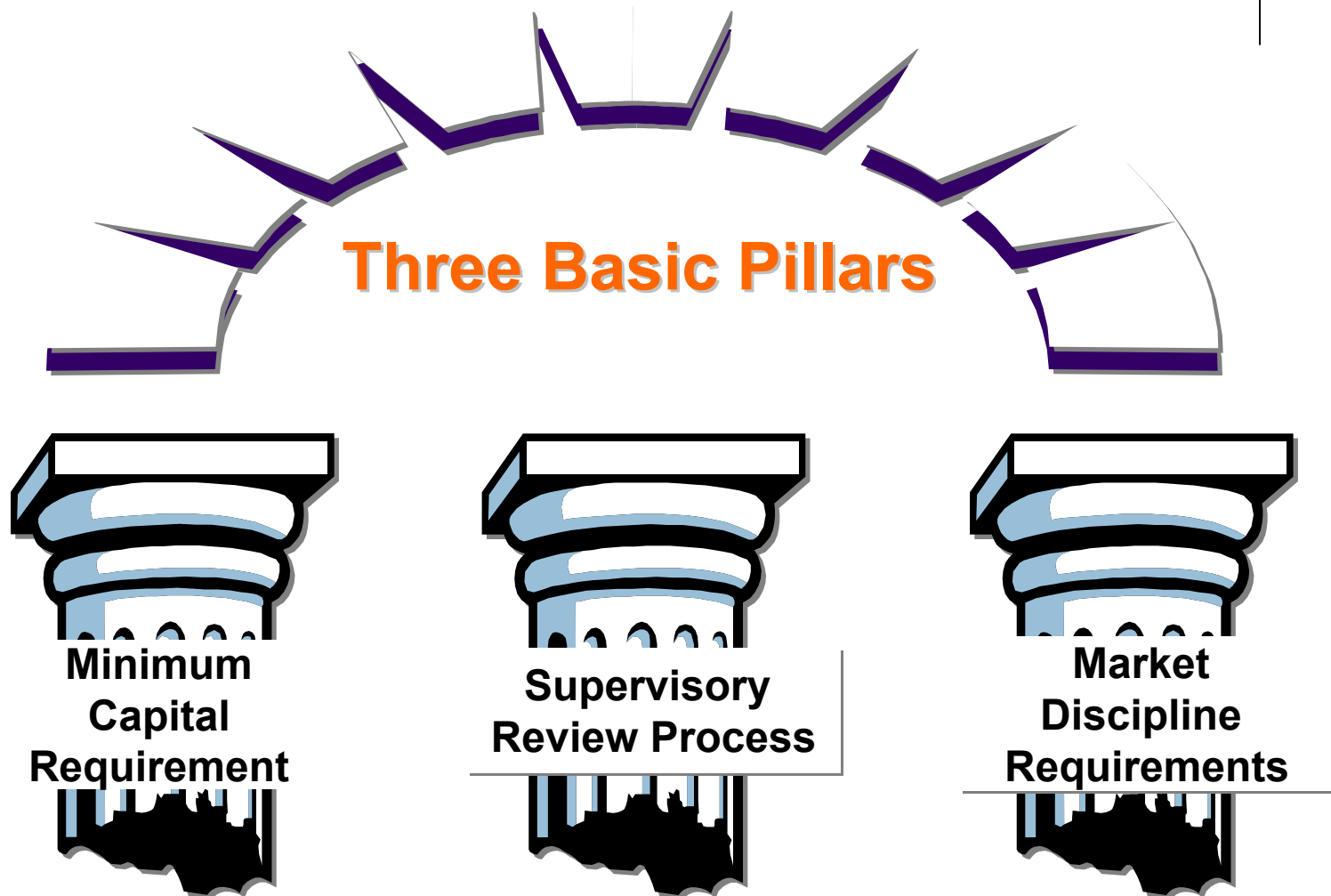
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# Regulatory Approach\*



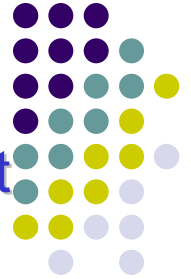
\* For more details, see Chapter-5, “Risk Management” by Crouhy, Galai and Mark

# The BIS Capital Adequacy Paper



# BIS Menu of Approaches

Should serve to encourage Best Practice Risk Management



## BIS 98

- **For Measuring Market Risk (in the Trading Room)**
  - Standardized Approach
  - Internal VaR Models Approach

## BIS 2006

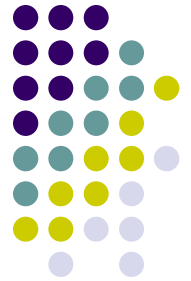
- **For Measuring Credit Risk (Jan. 2001)**
  - Standardized Approach
  - Foundation Internal Ratings-based Approach
  - Advanced Internal Ratings-based Approach

## BIS 2006

- **For Measuring Operational Risk (Jan. 2001)**
  - Basic Indicator Approach
  - Standardized Business Line Approach
  - Advanced Measurement Approach

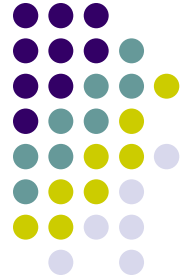


# BIS 2006 has the potential to be a great step forward



## What Are The Implications?

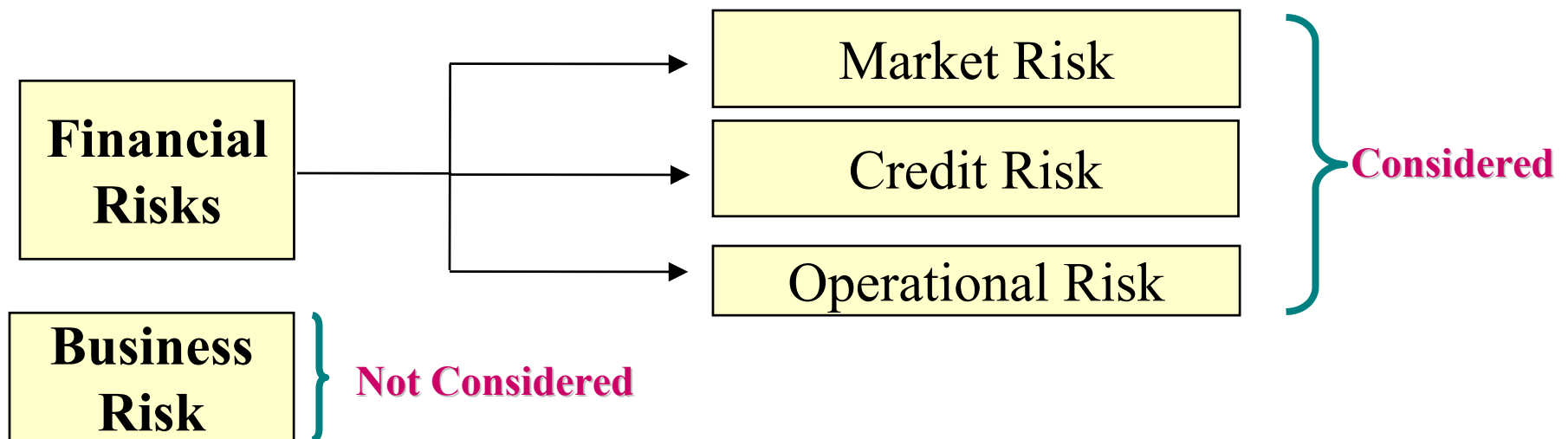
- An increasing sophistication
- A significant transformation
- An integration of risk measurements
- A greater transparency of risks
- A new way of managing risk
- Banks can differentiate themselves



# BIS 2006 Does Not Consider All Risk

Example:

BIS 2006 has the potential to be a great step forward but

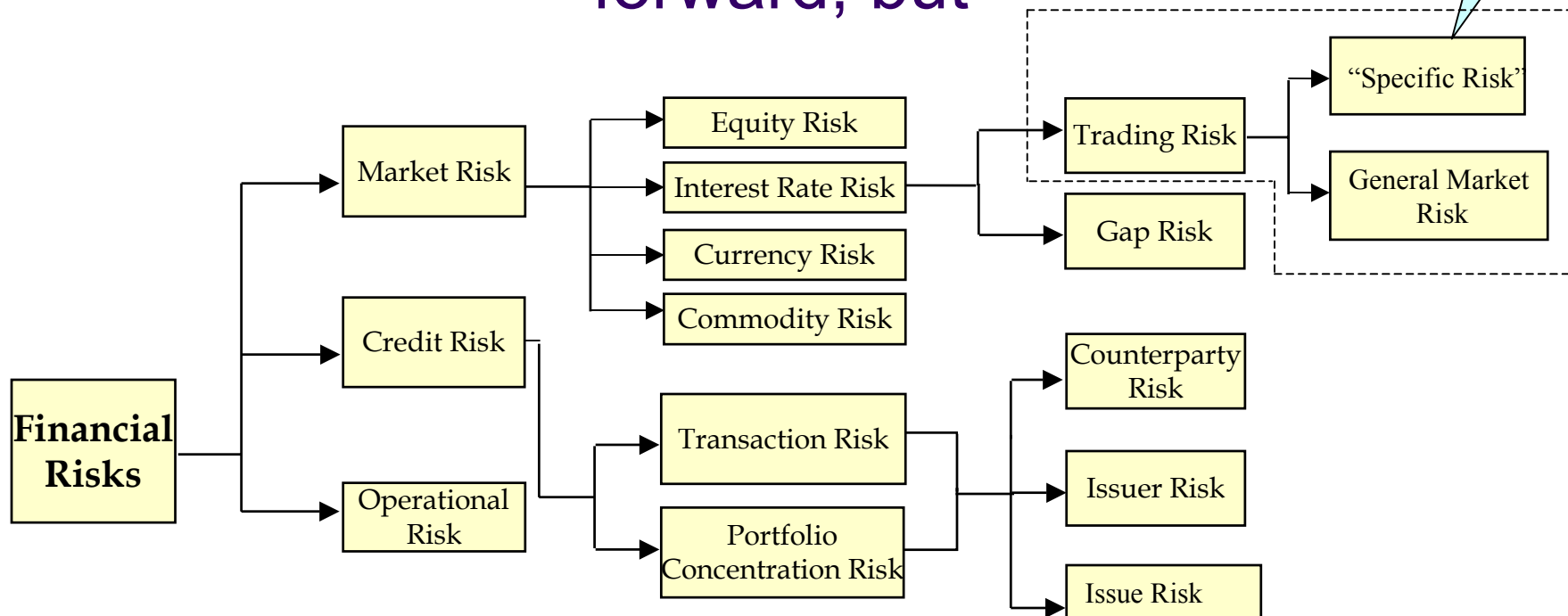


Business Risk is a key risk which ultimately cannot be ignored.

# BIS 98 Allowed for Internal Models, BIS 2006 Does Not

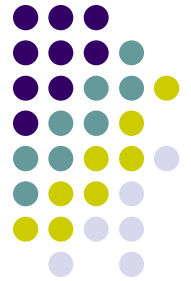
Example:  
Basle 2006 has the potential to be a great step forward, but

BIS 98



does not allow internal models for credit risk

# The 1998 BIS and CAD II Accord is a great step forward



**Applies to the trading book and encompasses:**

- **General market risk**
  - Change in market value resulting from broad market movements.
- **Specific risk  
(idiosyncratic or credit risk)**
  - Adverse price movements due to idiosyncratic factors related to individual issuers.

# BIS 98 Framework



- ...but also for a more accurate allocation of capital

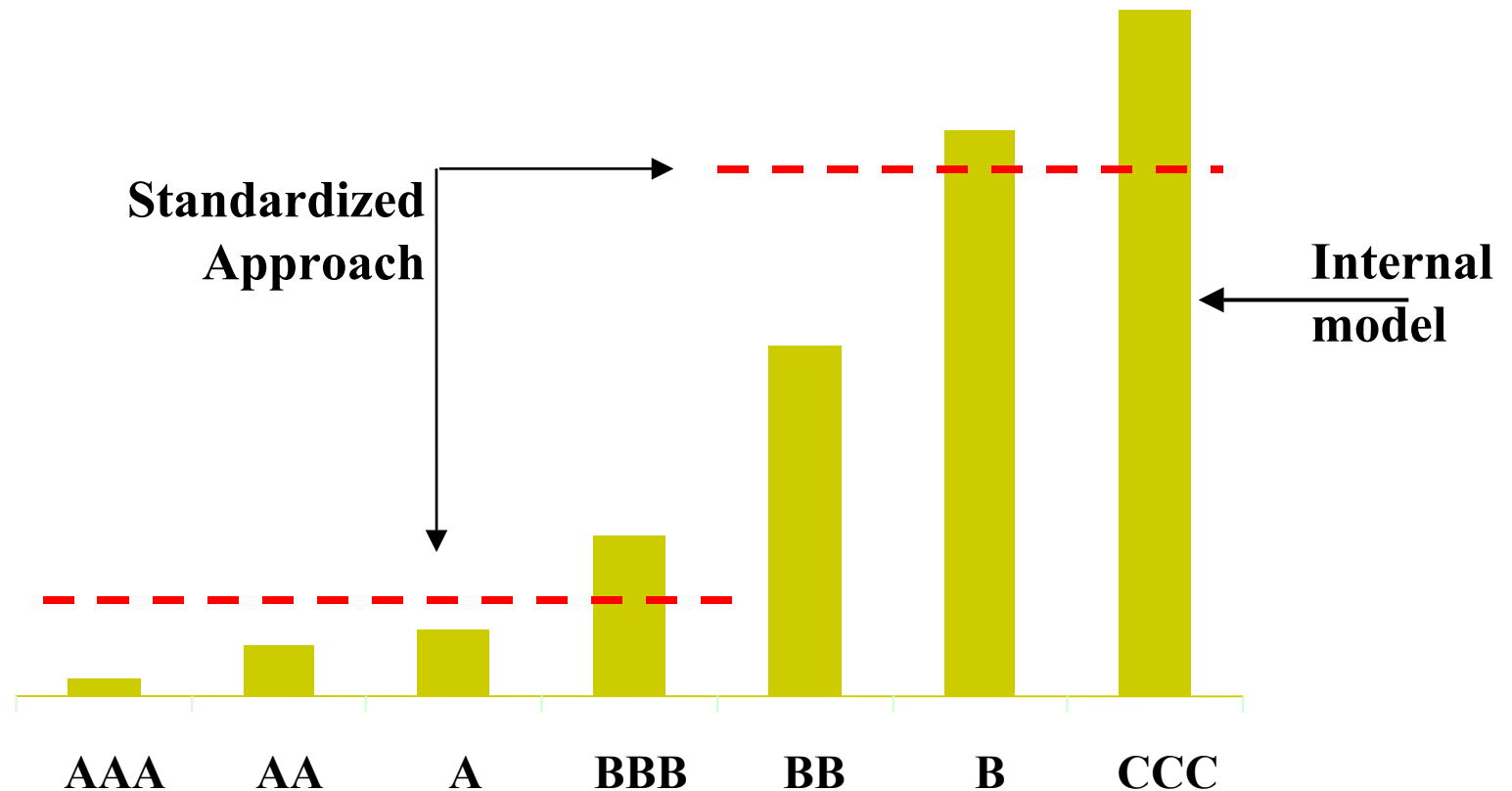
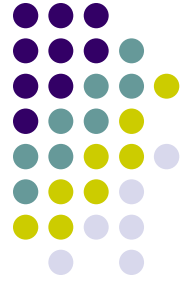
**Example:**

**Portfolio of  
100 \$1 bonds  
diversified across  
industries**

## Capital charge for specific risk (%)

	Internal model	Standardized approach
AAA	0.26	1.6
AA	0.77	1.6
A	1.00	1.6
BBB	2.40	1.6
BB	5.24	8
B	8.45	8
CCC	10.26	8

# BIS 98 Framework



# Standardized Approach: New Corporate Risk Weights (Jan. 2001)



CLAIM	Assessment					
	AAA to AA <sup>-</sup>	A <sup>+</sup> to A <sup>-</sup>	BBB <sup>+</sup> TO BBB <sup>-</sup>	BB <sup>+</sup> TO BB <sup>-</sup>	Below BB <sup>-</sup>	Unrated
Corporates	20%	50%	100%	100%	150%	100%

# Internal Ratings-Based Approach



## Risk Components

- **Foundation Approach**
  - **PD set by Bank**
  - **LGD, EAD, M set by Regulator**
    - 50% LGD for Senior Unsecured
    - 75% LGD for subordinated claims
    - LGD will be reduced by collateral (Financial or Physical)
    - EAD = 75% for irrevocable undrawn commitments <sup>1</sup>
    - M = 3 years
- **Advanced Approach**
  - **PD, LGD, EAD, M all set by Bank**
  - **Between 2005 and 2007: floor for advanced approach @ 90% of foundation approach**

### Notes

<sup>1</sup> 0% credit conversion factor applies for unconditionally and immediately cancelable commitments



# Standardized vs. Foundation IRB Approach

The Foundation Approach charges more capital for non-investment grade facilities and less for investment grade debt than the Standardized Approach



S&P Rating	1 Year Historical Default Probability %	Standardized		Foundation (Jan 2001)		Foundation Capital Charge Divided by Standardized Capital Charge
		Risk Weight %	Capital charge Per \$100 of Asset Value	Corporate BRW Risk Weight <sup>1</sup> %	IRB Capital Charge per \$100 of Asset Value (LGD = 50%)	
AAA	.01	20	1.6	7	0.56	.35
AA	.03	20	1.6	14	1.12	.70
A	.04	50	4	17	1.34	.34
BBB	.22	100	8	48	3.83	.48
<b>Benchmark</b>	<b>.70</b>	<b>100</b>	<b>8</b>	<b>100</b>	<b>8</b>	<b>1</b>
BB	.98	100	8	123	9.87	1.23
B	5.30	150	12	342	27.40	2.28
CCC	21.94	150	12	694	50 (55.55)	4.16

Capital Charge for Standard and Poor's Rating Categories  
BRW = Benchmark Risk Weight



# Foundation vs. Internal Model Approach

**Foundation IRB attributes more than twice as much capital as Internal Models (ISDA)**

S&P Rating	1 Year Historical Default Probability %	Foundation		ISDA	Foundation Capital Charge Divided by ISDA Capital Charge
		Corporate BRW Risk Weight <sup>1</sup> %	IRB Capital Charge per \$100 of Asset Value (LGD = 50%)	Capital Charge Incl. EL (LGD = 50%)	
AAA	.01	7	0.56	0.30	1.9
AA	.03	14	1.12	0.44	2.5
A	.04	17	1.34	0.59	2.3
BBB	.22	48	3.83	1.95	2.0
<b>Benchmark</b>	<b>.70</b>	<b>100</b>	<b>8</b>	<b>4.36</b>	<b>1.8</b>
BB	.98	123	9.87	5.24	1.9
B	5.30	342	27.40	17.12	1.6
CCC	21.94	694	50 (55.55)	49.75	1.0

BRW = Benchmark Risk Weight

# Typology of OR

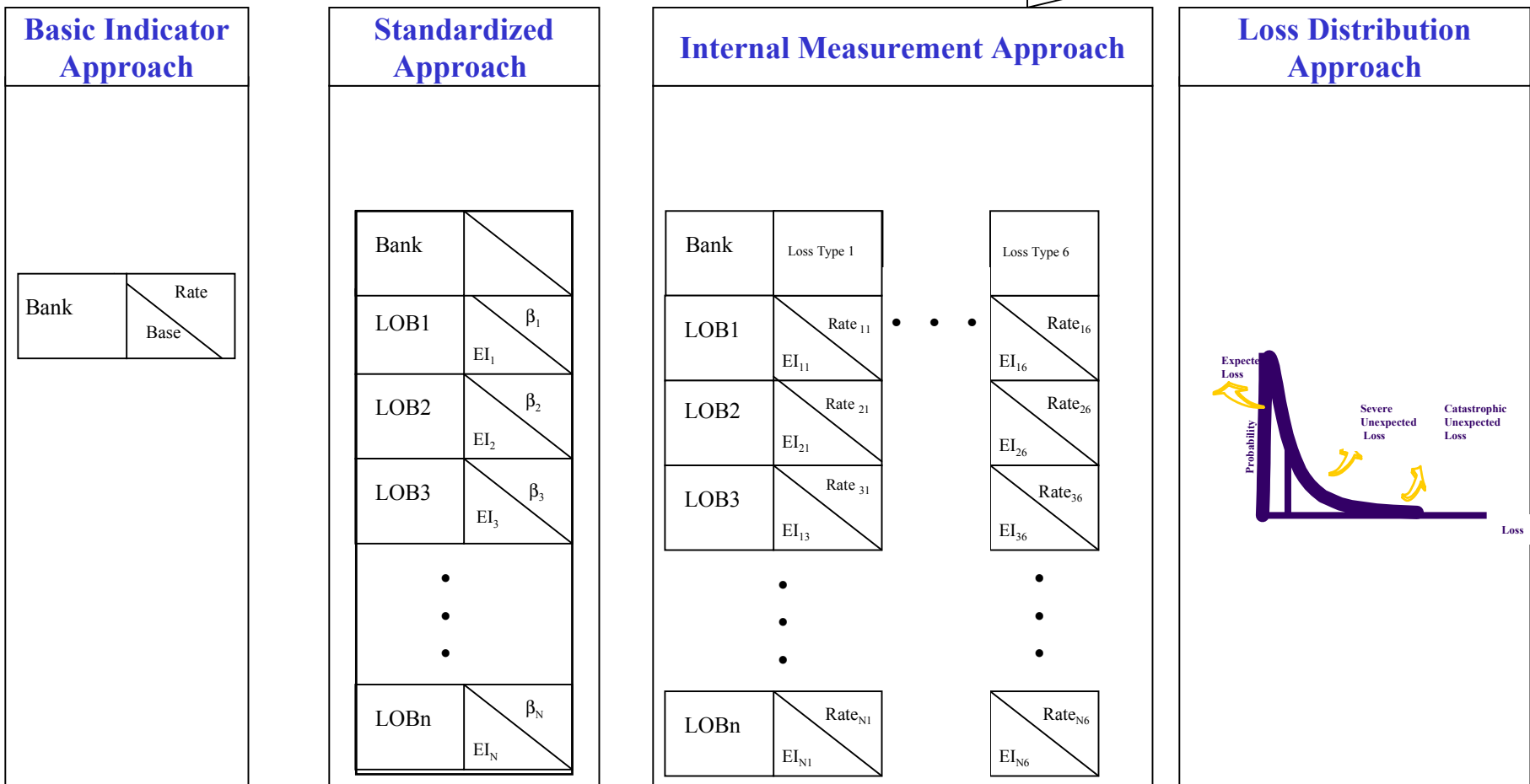


- **Practitioners and Regulators have defined OR as the potential for loss due to the failure of people, process & technology.**
- **A key challenge for academic researchers is to create a relevant normative theory for OR.**
- **A key challenge for academic researchers and practitioners is to objectively quantify OR as well as to develop models to determine the price of OR insurance.**

# The Regulatory Approach To Operational Risk: Four Increasingly Risk Sensitive Approaches



**Risk Based/ less Regulatory Capital:**



# The Internal Measurement Approach

Is a step in the right direction



$$\text{Op Risk Capital (OpVaR)} = \text{EI}_{\text{LOB}} \times \underbrace{\text{PE}_{\text{LOB}} \times \text{LGE}_{\text{LOB}} \times \gamma_{\text{industry}}}_{\text{Rate}} \times \text{RPI}_{\text{LOB}}$$

$\underbrace{\text{LR}_{\text{firm}}}_{\text{Rate}}$

EI	=	Exposure Index e.g. no of transactions * average value of transaction
PE	=	Expected Probability of an operational risk event e.g. number of loss events / number of transactions
LGE	=	Average Loss Rate per event e.g. average loss/ average value of transaction
LR	=	Loss Rate (PE x LGE)
$\gamma$	=	Factor to convert the expected loss to unexpected loss
RPI	=	Adjusts for the non-linear relationship between EI and OpVar (RPI = Risk Profile Index)



# Examples of Operational Risk Losses Types

## 1. Legal Liability:

includes client, employee and other third party law suits

## 2. Regulatory, Compliance and Taxation Penalties:

finer, or the cost of any other penalties, such as license revocations and associated costs - excludes lost / forgone revenue.

## 3. Loss of or Damage to Assets:

reduction in value **of the firm's non-financial asset and property**

## 4. Client Restitution:

includes restitution payments (principal and/or interest) or other compensation to clients.

## 5. Theft, Fraud and Unauthorized Activities:

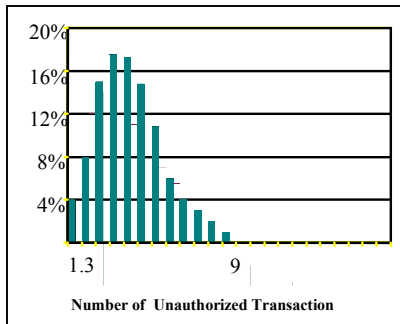
includes rogue trading

## 6. Transaction Processing Risk:

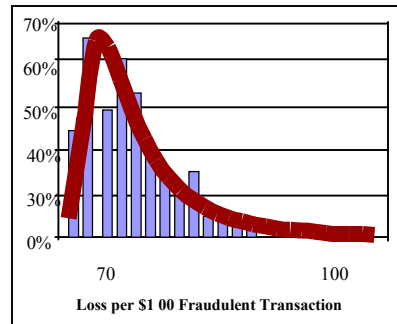
includes failed or late settlement, wrong amount or wrong counterparty

# The Components of OP VaR

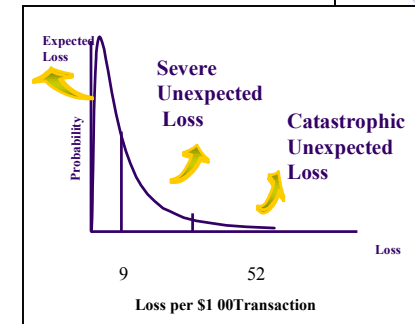
e.g. VISA Per \$100 transaction



+



=



*The Probability Distribution*

$PE = .13\%$

*e.g. on average 1.3 transaction per 1,000 (PE) are fraudulent*

*Note: worst case is 9*

*The Severity Distribution*

$LGE = \$70$

*e.g. on average 70% (LGE) of the value of the transaction have to be written off*

*Note: worst case is 100*

*The Loss Distribution*

$LR = 9\text{¢}^1$

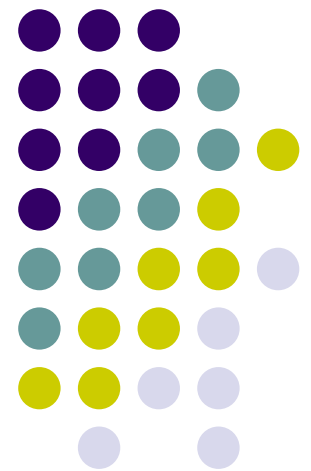
*e.g. on average 9.1 cents per \$100 of transaction (LR)*

*Note: worst case is 52*

Note: <sup>1</sup>  $LR = PE \times LGE = 0.13\% \times \$70 = 9.1 \text{ cents}$

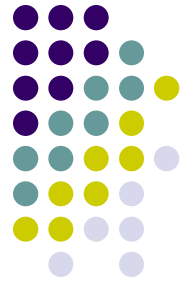
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# Transforming Risk into Value\*



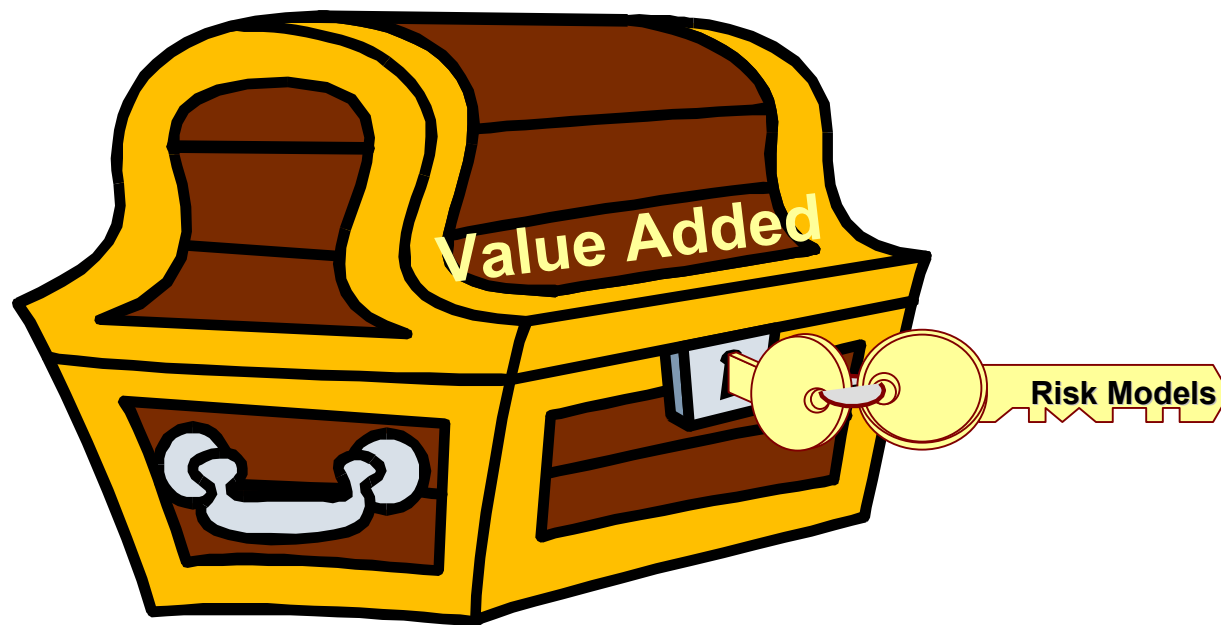
\* For more details, see “Risk Management” by Crouhy, Galai and Mark



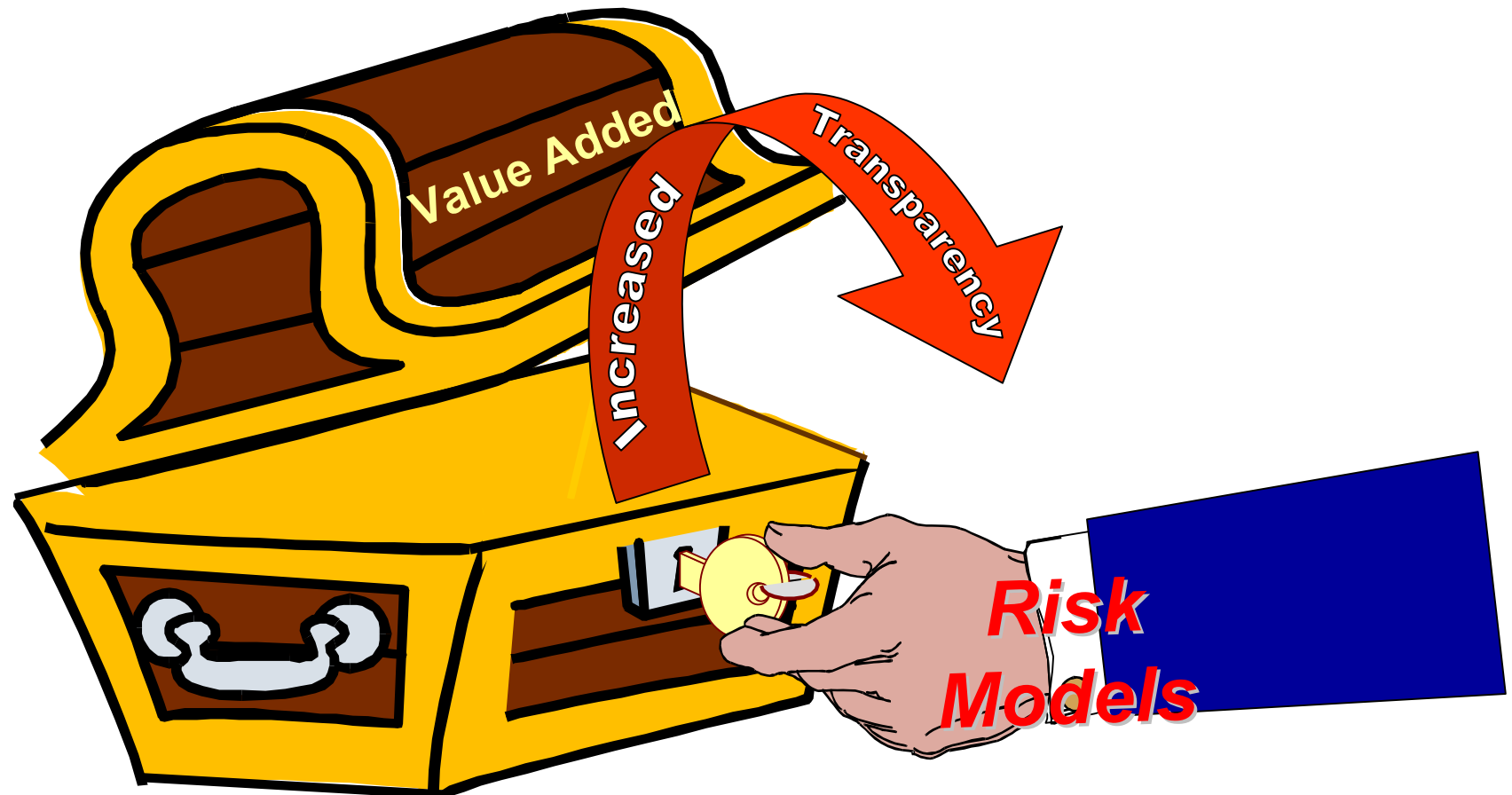


# Transforming Risk into Value

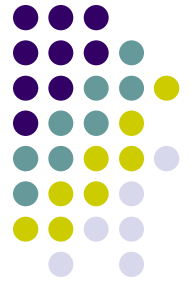
- Implementation of Risk Models is a key input



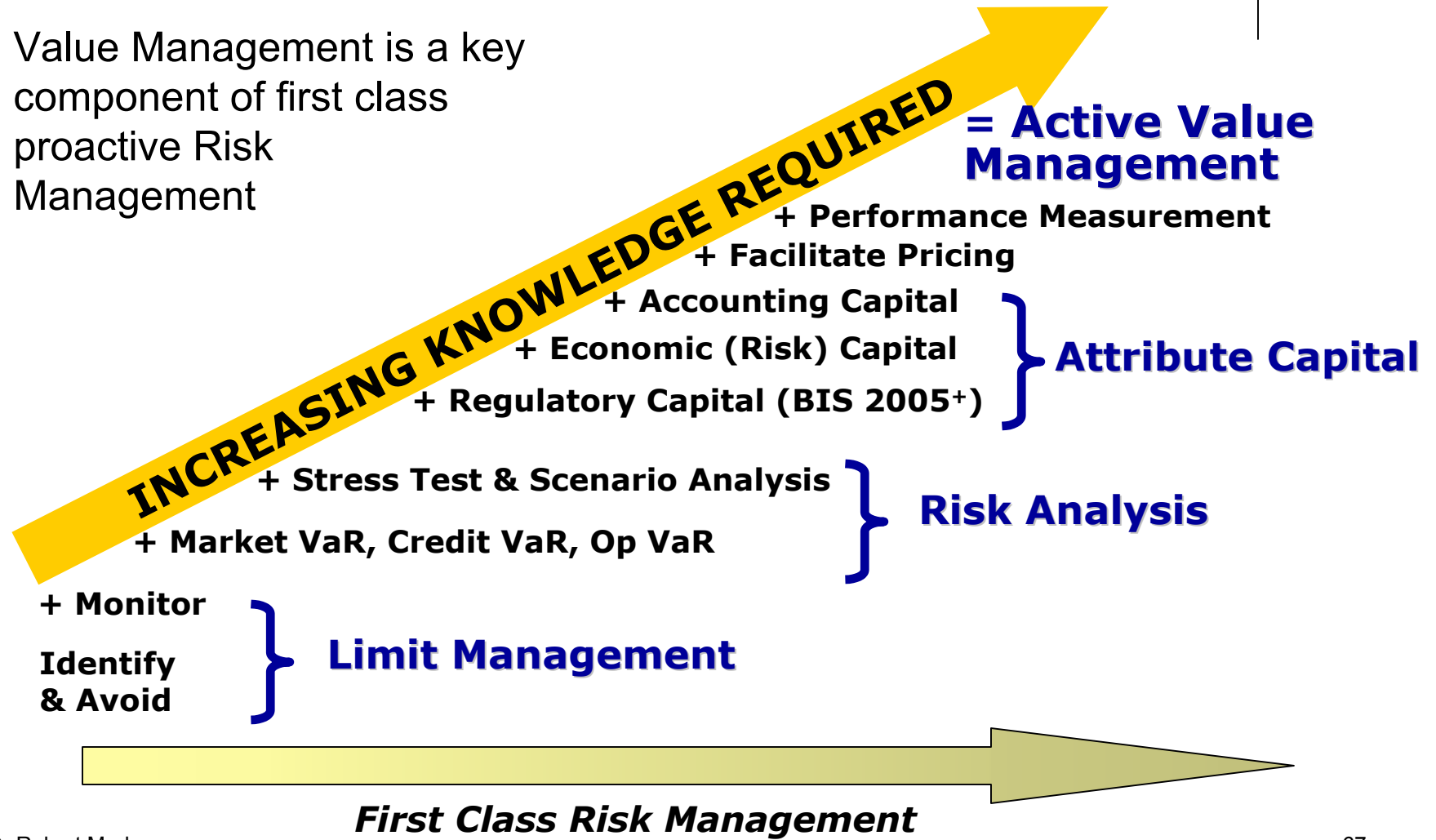
# Transforming Risk into Value



# Transforming Risk into Value

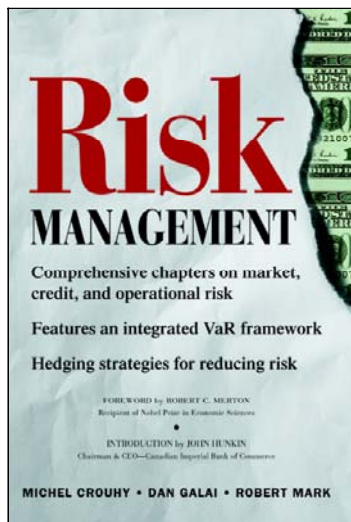


- Value Management is a key component of first class proactive Risk Management



## Appendix

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