

The Intermediation of Financial Risks:  
Lessons from the Catastrophe Reinsurance Market

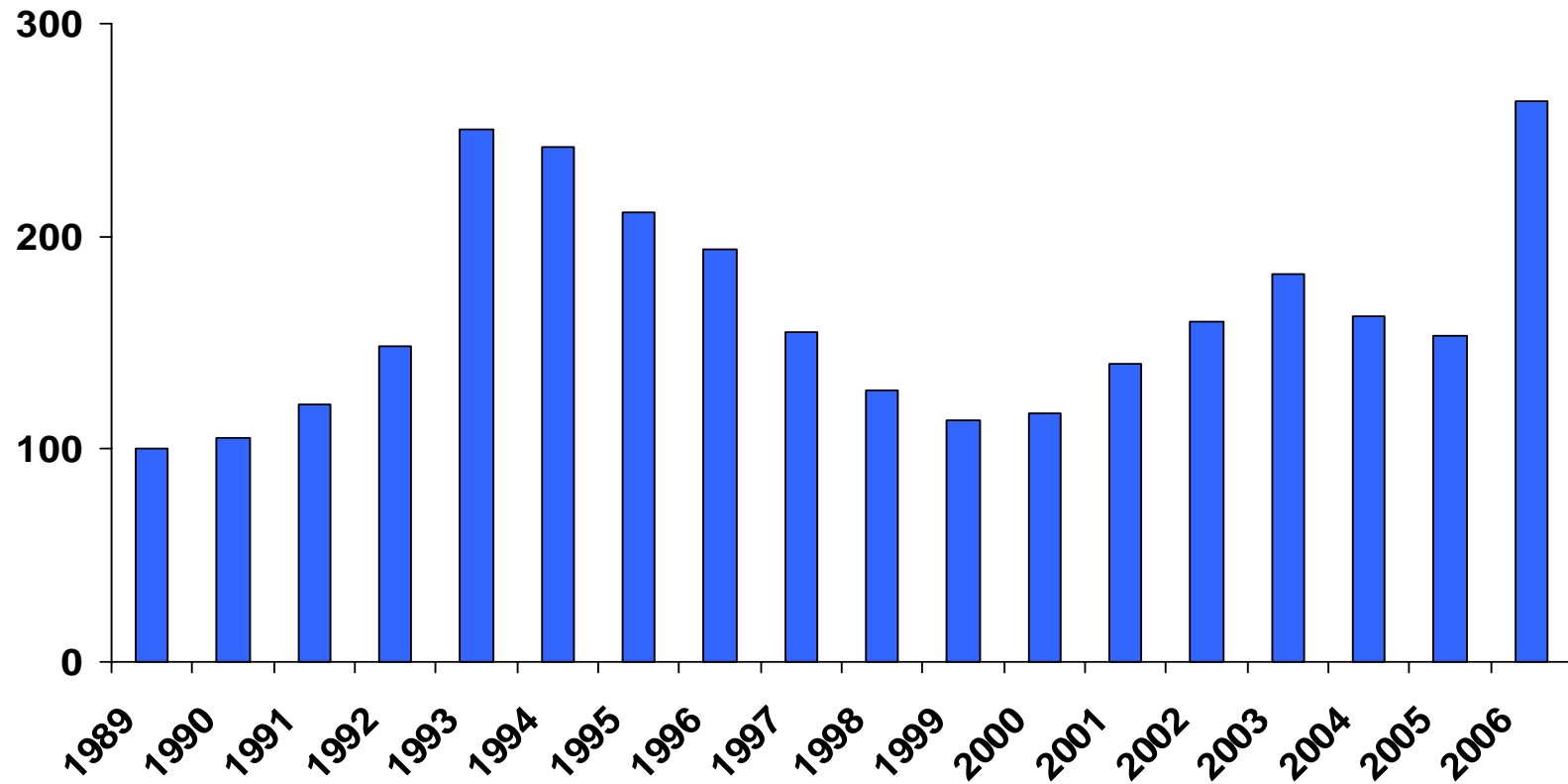
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## Despite Rapid Growth in Derivatives Markets....

- Financial intermediation of risk is improving, but remains imperfect
  - Opportunity and danger for the private sector
  - Laboratory for academics
- How can we know this?
- Catastrophe reinsurance markets are a place to look
  - Risks are far more objective than in other markets
  - Risks are not systematic and therefore can be priced as risk neutral
- What evidence is there?
  - from prices
  - from quantities

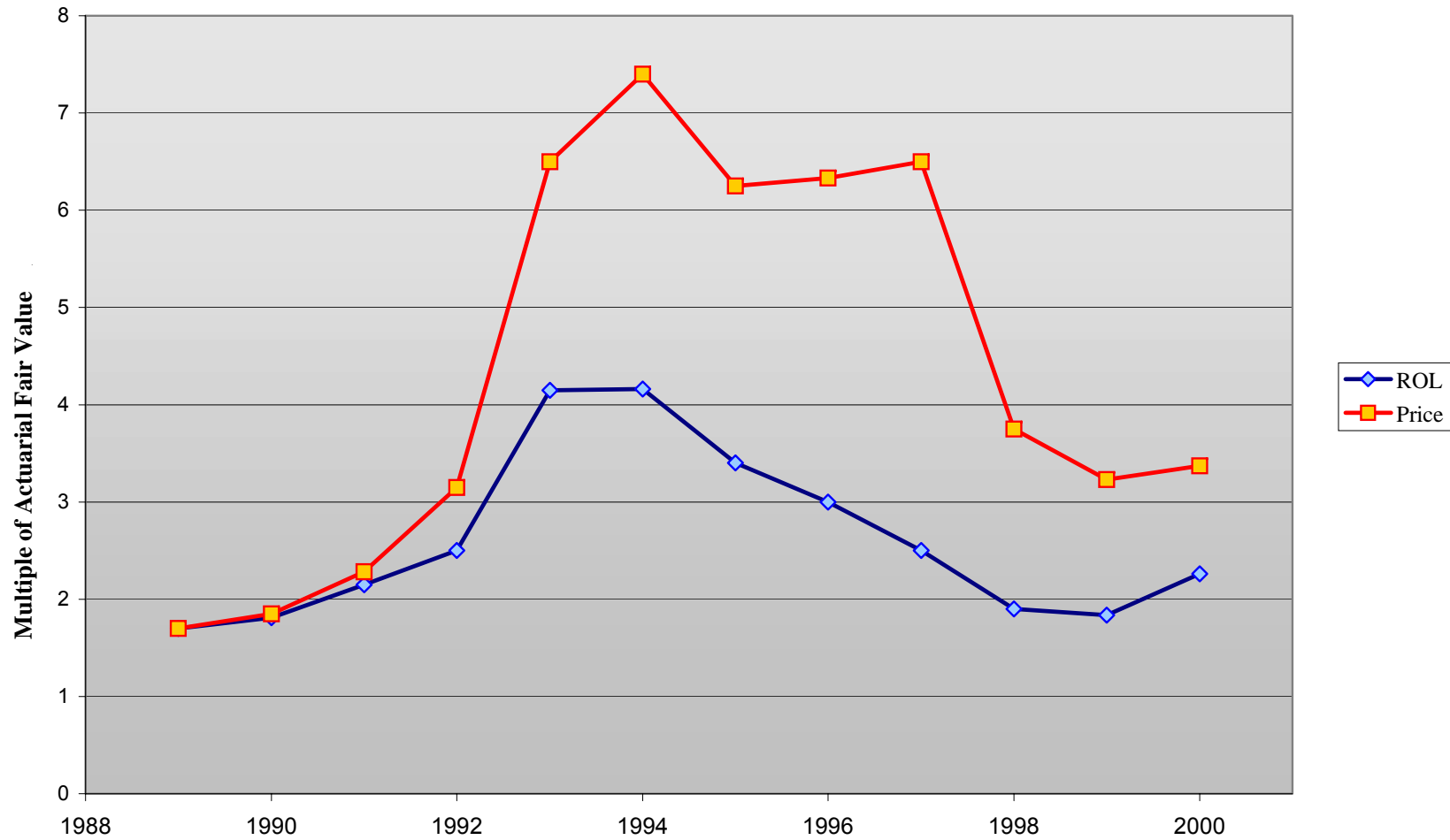
# U.S. Cat Property: Rate On Line\*

(Premiums for a call spread for a given limit and retention)



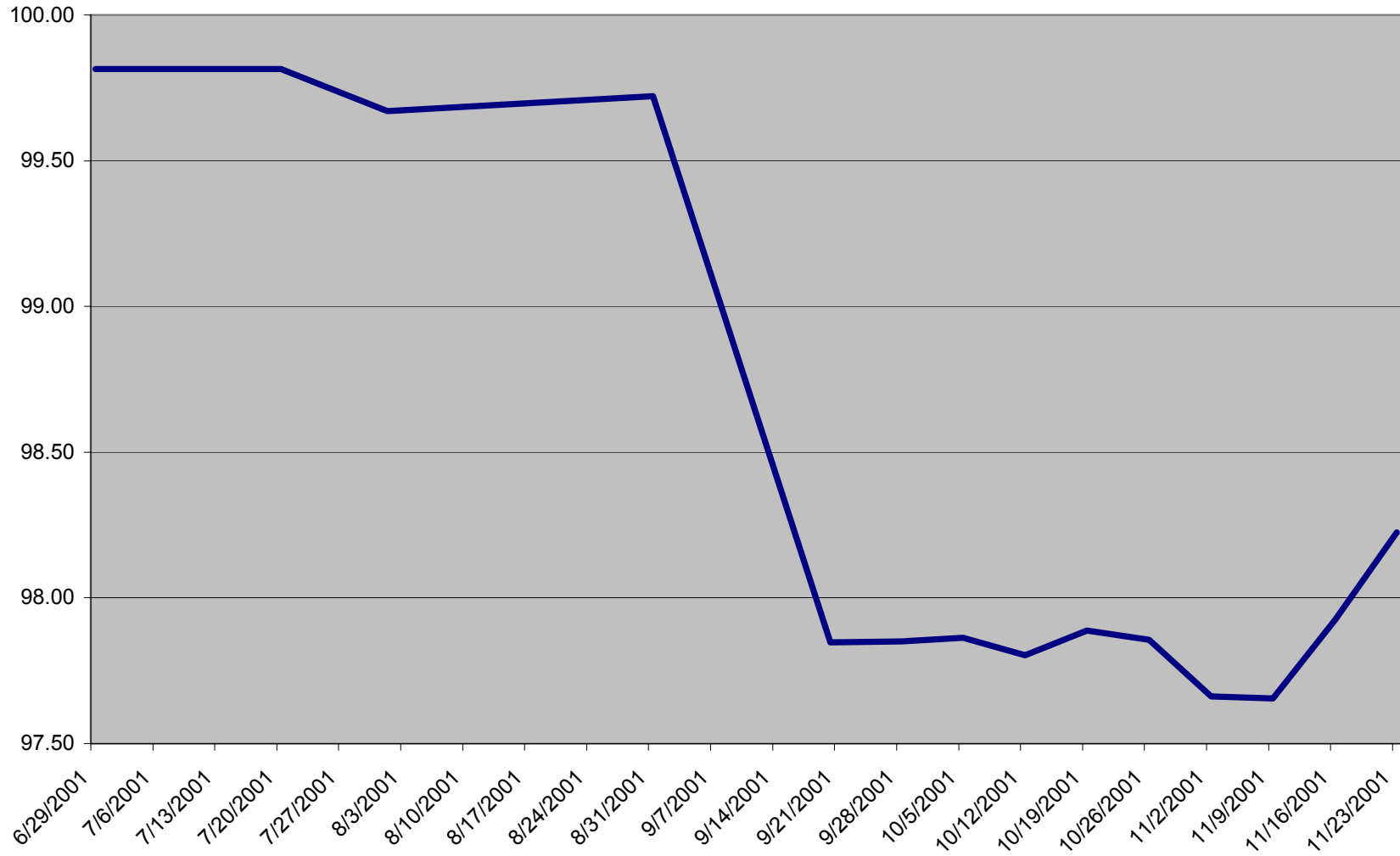
# Price: Premium / Expected Loss

Figure : Price of Reinsurance Relative to Actuarial Value, 1989-2000



# The Impact of Unrelated Perils on Prices

## 9/11 and Cat Bond Prices



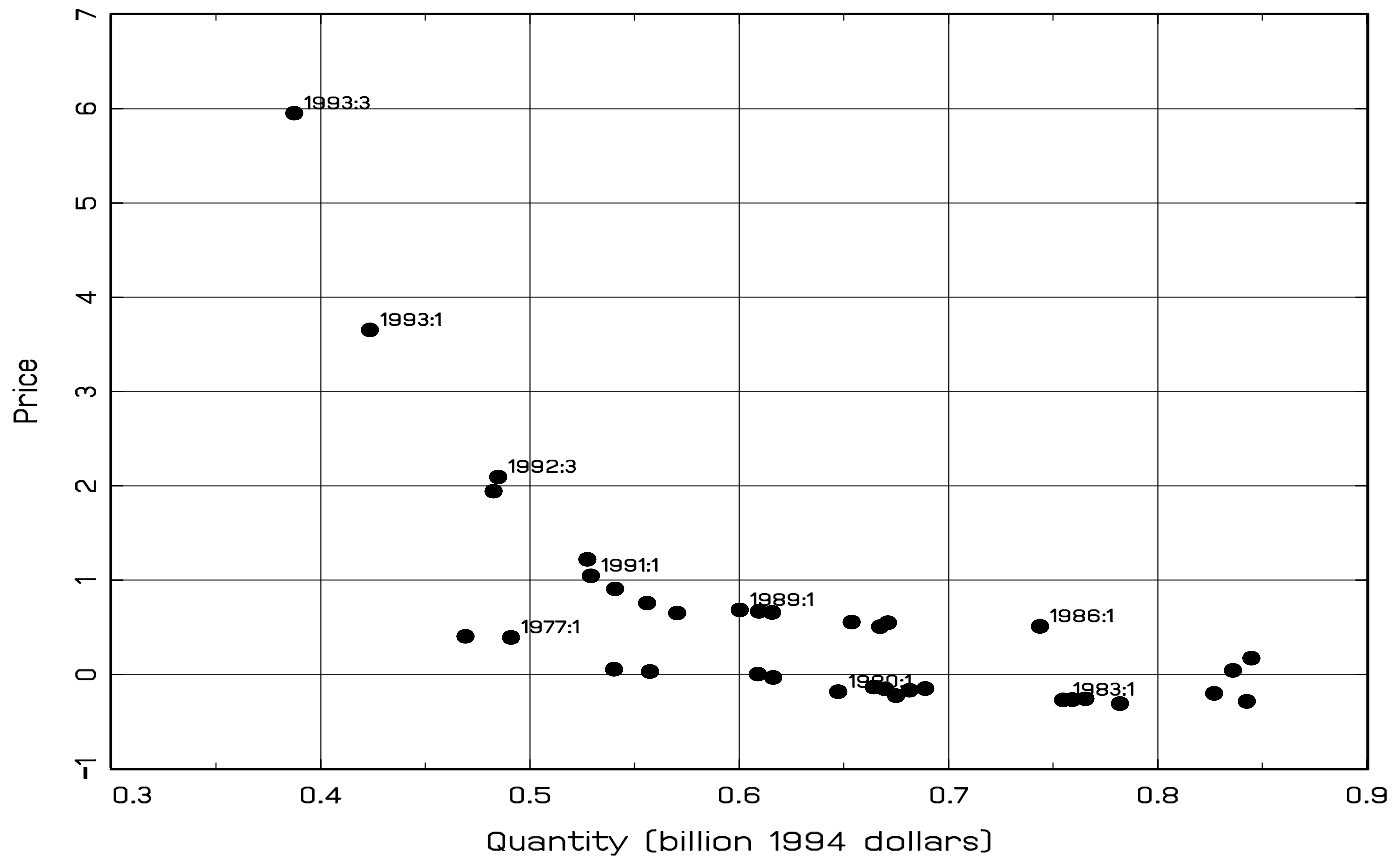
## Impact of KRW on Rate on Line

<u>Region</u>	<u>Strike</u>	<u>Expected Loss</u>	<u>2005</u>	<u>2006</u>
US hurricane	\$50B	2.5%	1.4x	6x*
US hurricane	\$30B	4.9%	1x	5.1x
US hurricane	\$20B	8.1%	1.4x*	4x
US earthquake	\$15B	4.3%	1.7x	3.5x
US earthquake	\$20B	3.2%	1.8x	3.6x
US 2 <sup>nd</sup> event	\$10B	5.2%	1.4x	4.8x
US 2 <sup>nd</sup> event	\$20B	1.2%	n/a	10.4x

Pricing shown as a spread to risk-free (typically 3m UST)

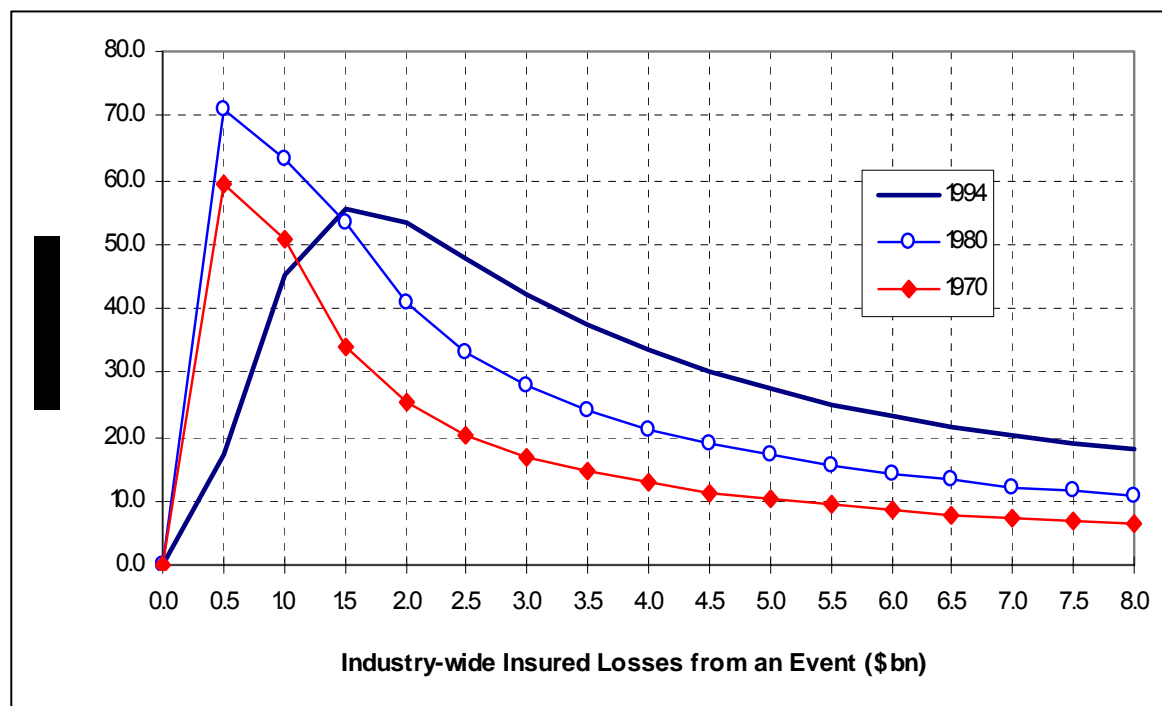
Expected losses shown as market standard model output (not NCL estimates)

# Reinsurance Price / Quantity Pairs



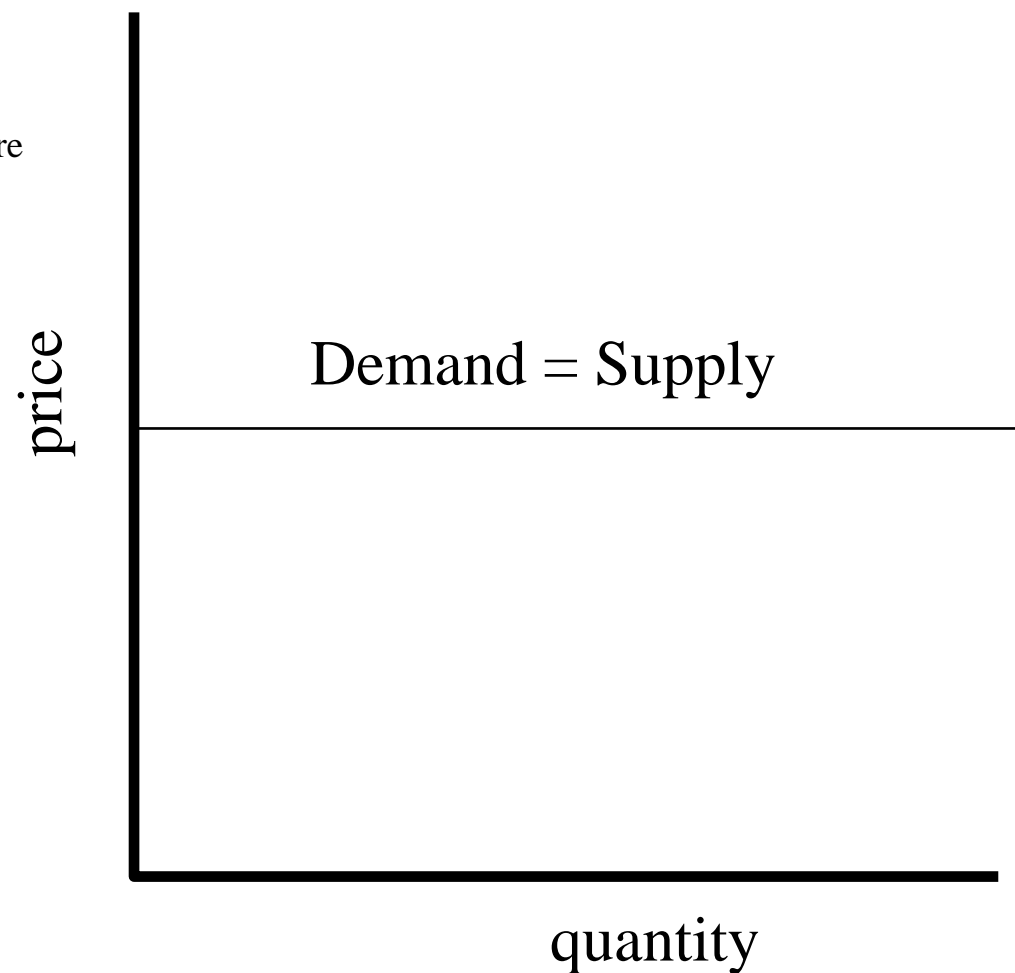
## The Quantity of Risk Transfer Should be High with Perfect Markets

- In the insurance industry, at least, the numbers have been low



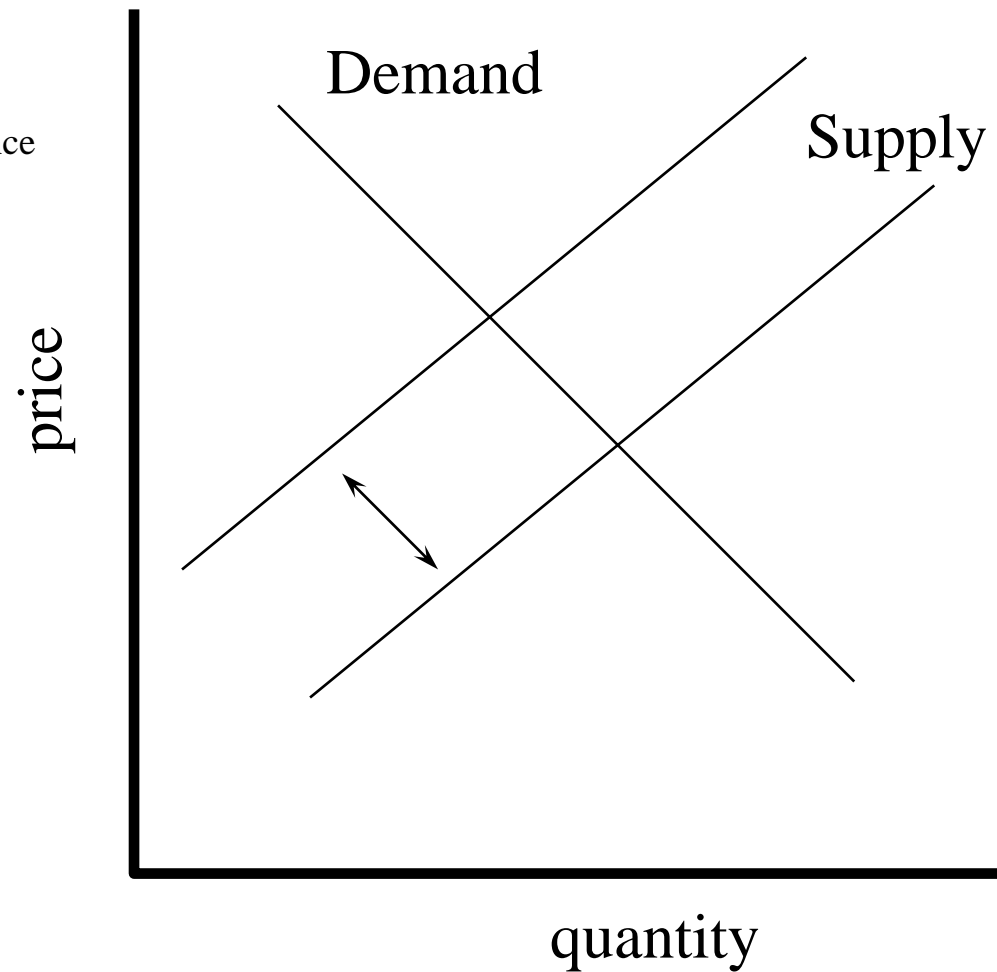
## Why can't we do better? Where are the frictions with the corporate form of financial intermediation?

- In a perfect world
  - elasticity of supply and demand are high



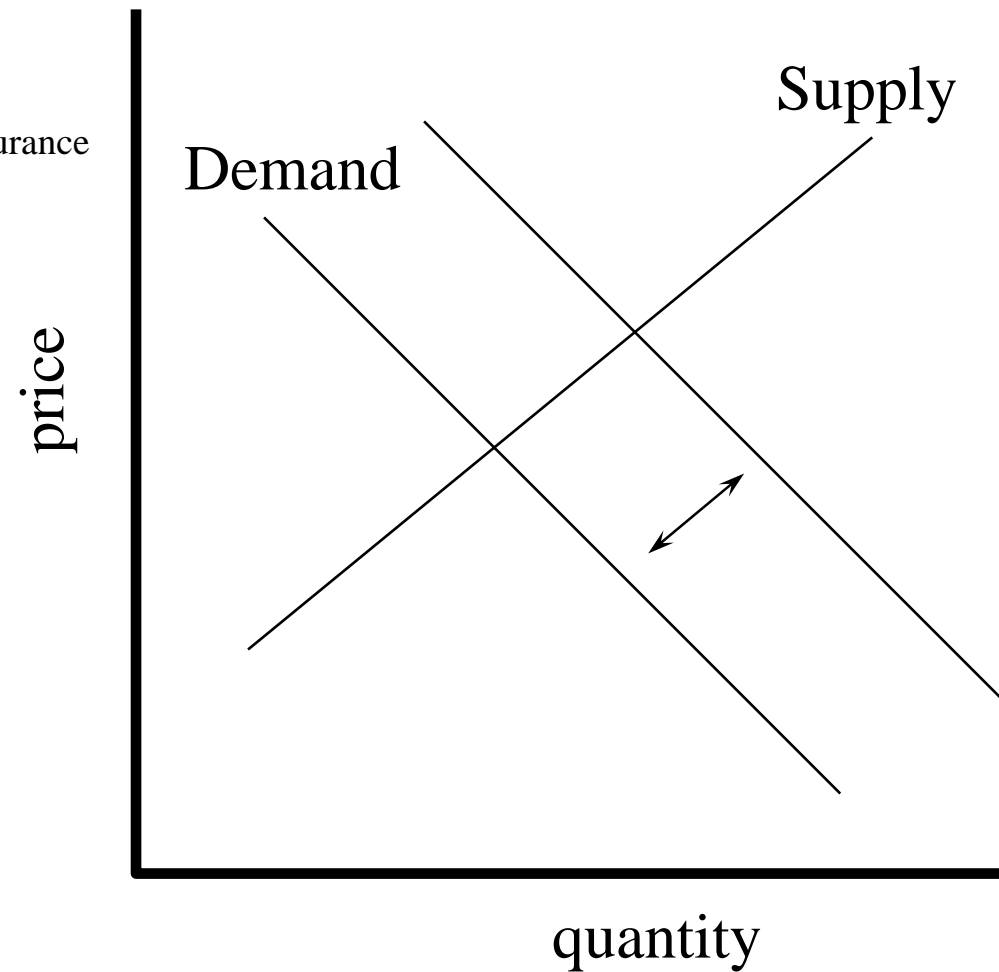
## What distortions diminish risk transfer?

- Two types of explanations
  - 1. Supply of Insurance/Reinsurance capacity is variable



## What distortions diminish risk transfer?

- Two types of explanations
  - 2. Demand for Insurance / Reinsurance capacity is variable



## What distortions diminish risk transfer?

- Supply is low (and prices high) because
  - 1. Reinsurance capital is expensive for some reason
  - 2. Insurers, reinsurers have market power
  - 3. The private reinsurance production process is inefficient
  - 4. Moral hazard / adverse selection
- Demand is low because
  - 5. Awareness is low (also, mitigation is low)
  - 6. Insurers are regulated, and regulation suppresses final price
  - 7. Ex-post subsidies expected from governments
  - 8. Behavioral factors make unlikely events seem irrelevant

## What Can These Facts Tell Us About the Structure of Financial Intermediation?

- Insurance and Reinsurance most typically done through the Corporate Form, i.e. companies that raise discretionary open-ended equity funding from shareholders
  - Under ‘classical’ corporate finance, open-ended discretion is efficient
  - Under ‘post-modern’ corporate finance, it is not
- More efficient hybrids seem to be emerging that disintermediate the discretion of corporate managers
  - Cat bonds, Industry Loss Warranties, and other insurance-linked securities
  - Investment management companies
  - CDOs

## Simple Intermediation: The Corporate Form

- Insurers face *costs of depleting* capital because, once depleted
  - It's expensive to raise it
  - It discourages customers, who want a riskless not 'probabilistic' insurance product
- Insurers also face *costs of hoarding* capital because
  - Its inefficient to warehouse unused capital in taxable corporations
  - It can be dangerous and risky to give managers additional capital subject to their discretion
- In the world of classical finance, these costs don't exist
  - In the real world, they do

# Costs of Depleting Capital: Capital market imperfections

- Theory
  - Costs of running below target levels of capital. ‘Bankruptcy’ or ‘underinvestment’ costs result because external funds are costly, making risk management a potentially valuable activity (Myers, Myers and Majluf, Froot, Scharfstein, Stein, and Froot and Stein).
  - In classical finance, if you are running low on capital, go get more from the market at the fair price
- Evidence
  - Many studies suggesting that firms cut back on profitable investment and other spending when cash is tight (e.g., Gilson, Gertner and Scharfstein, Andratti, Kaplan and Zingales, Lamont).

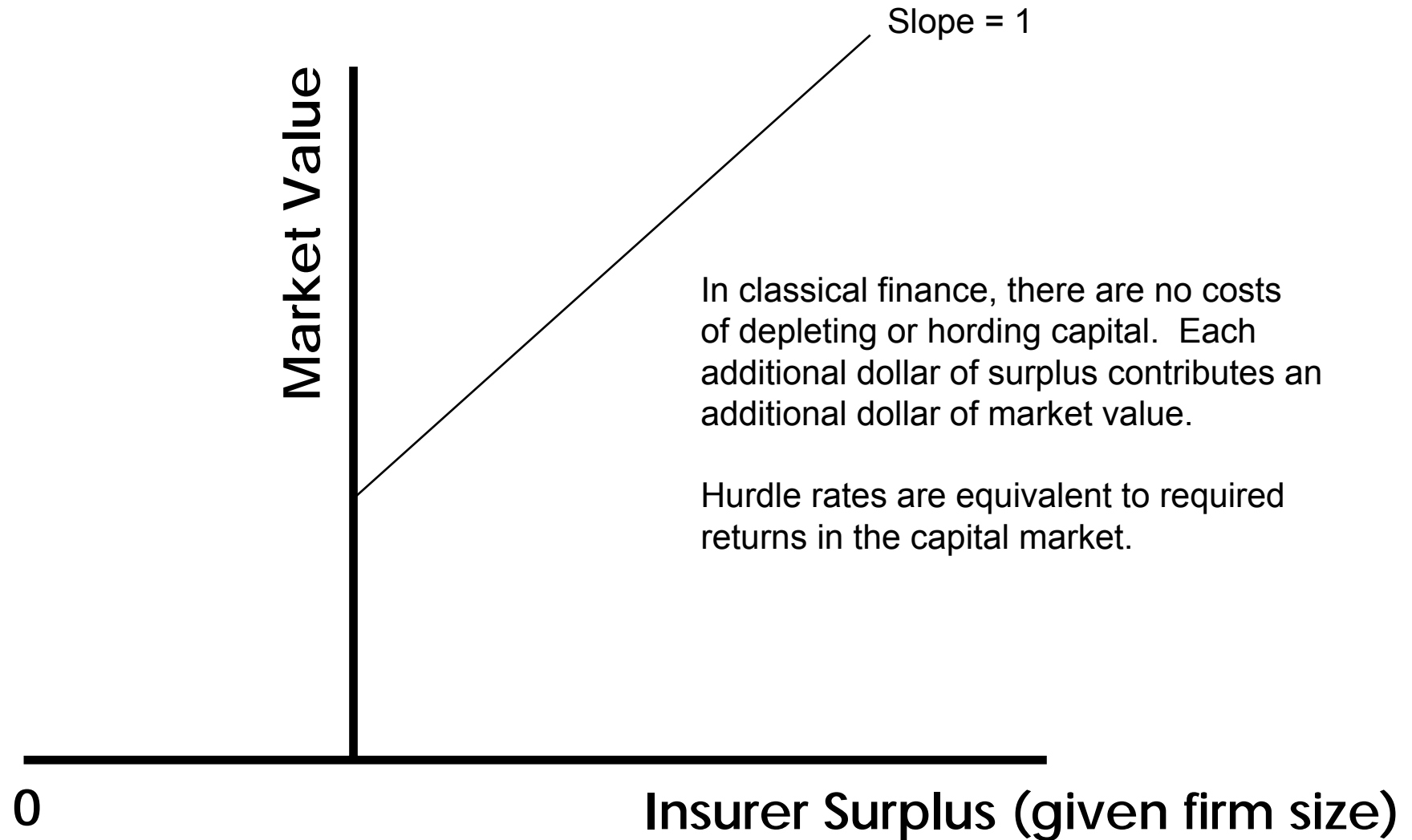
# Costs of Depleting Capital: Probabilistic insurance

- **Definition**
  - Risky payoffs discounted more severely by customers than by rational investors (not true in classical finance)
- **Theory:**
  - Behavioralist: Zechauser's Roulette introspection and Prospect theory
  - Rationalist: costly customer diversification, state contingent marginal utility, and 'hassles'
  - Incorporated into insurance models by Zanjani, Cummins and Danzon, Cummins and Sommer, Taylor, and Hoerger, Sloan, and Hassan.
- **Evidence**
  - Linkage of insolvency risk to pl premiums - Evidence that profitability is positively related to surplus/assets (Sommer)
  - NY and FL homeowners pay higher premiums to better rated insurers, particularly for exposures above those guaranteed (Grace, Klein, and Kleindorfer)
  - Higher Best rated firms grew faster after ratings change (Epermanis and Harrington)
  - Survey evidence (Wakker, Thaler and Tversky)
  - Price discounting is 10x-20x (Philipps, Cummins, and Allen)

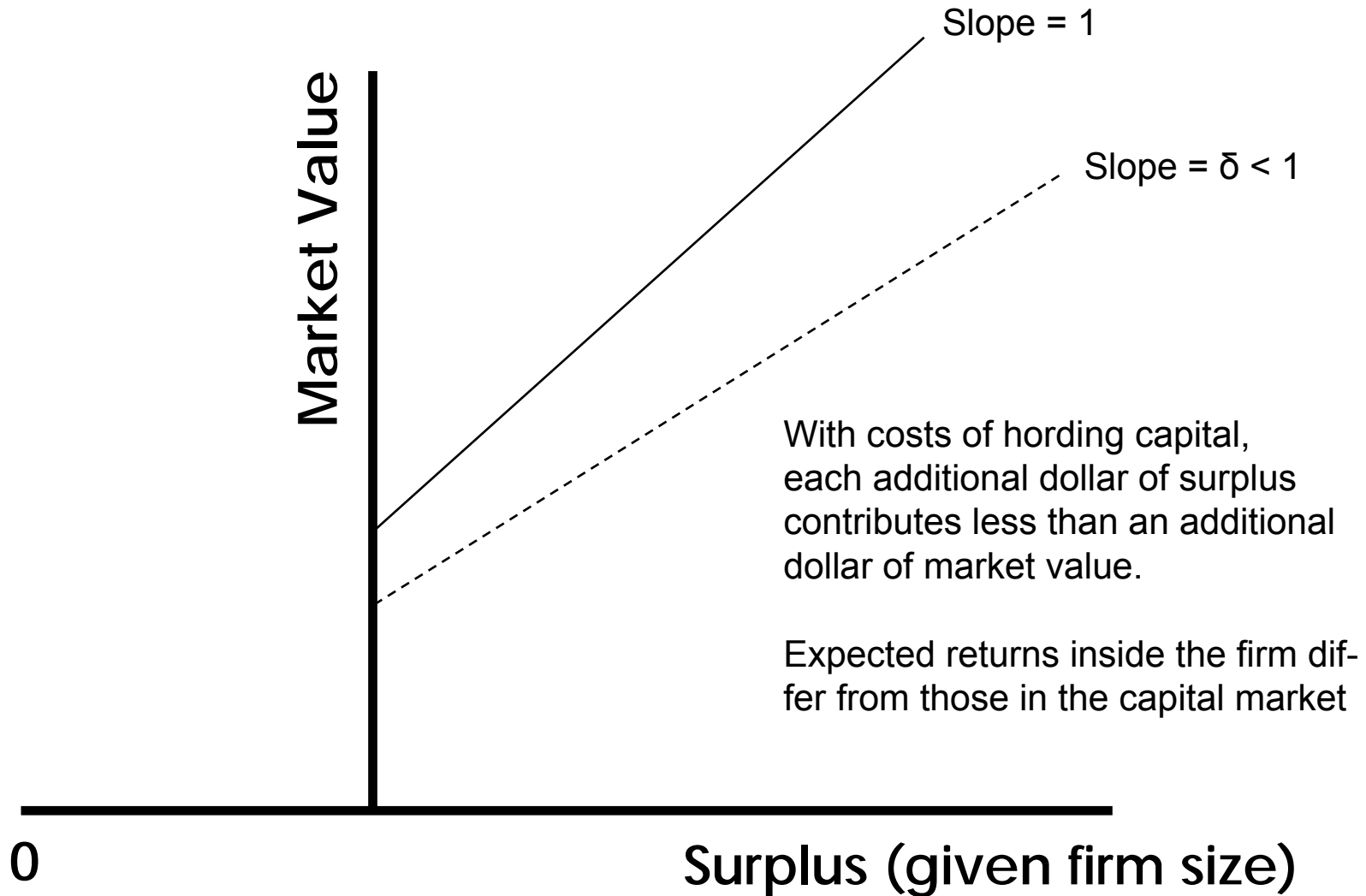
## Costs of Hording Capital: Tax and agency issues

- Theory
  - Capital markets prefer limits on managerial discretion, imposed by using less capital and/or debt finance (Jensen, Miller, many others)
  - In classical finance, managers act just like owners
- Evidence
  - Firms with greater discretion of managers seem to diversify too much (Wruck)
  - Bidder stock prices fall and targets rise in takeovers (Ruback, many others)
  - Value increases less than one-for-one when well-funded firms receive surprise legal awards (Shleifer and Vishny)
  - Closed-end funds are on average worth less than their net assets (Lee, Shleifer and Thaler, Pontif, Bodurtha, Kim and Lee, Hardouvelis, La Porta, and Wizman)

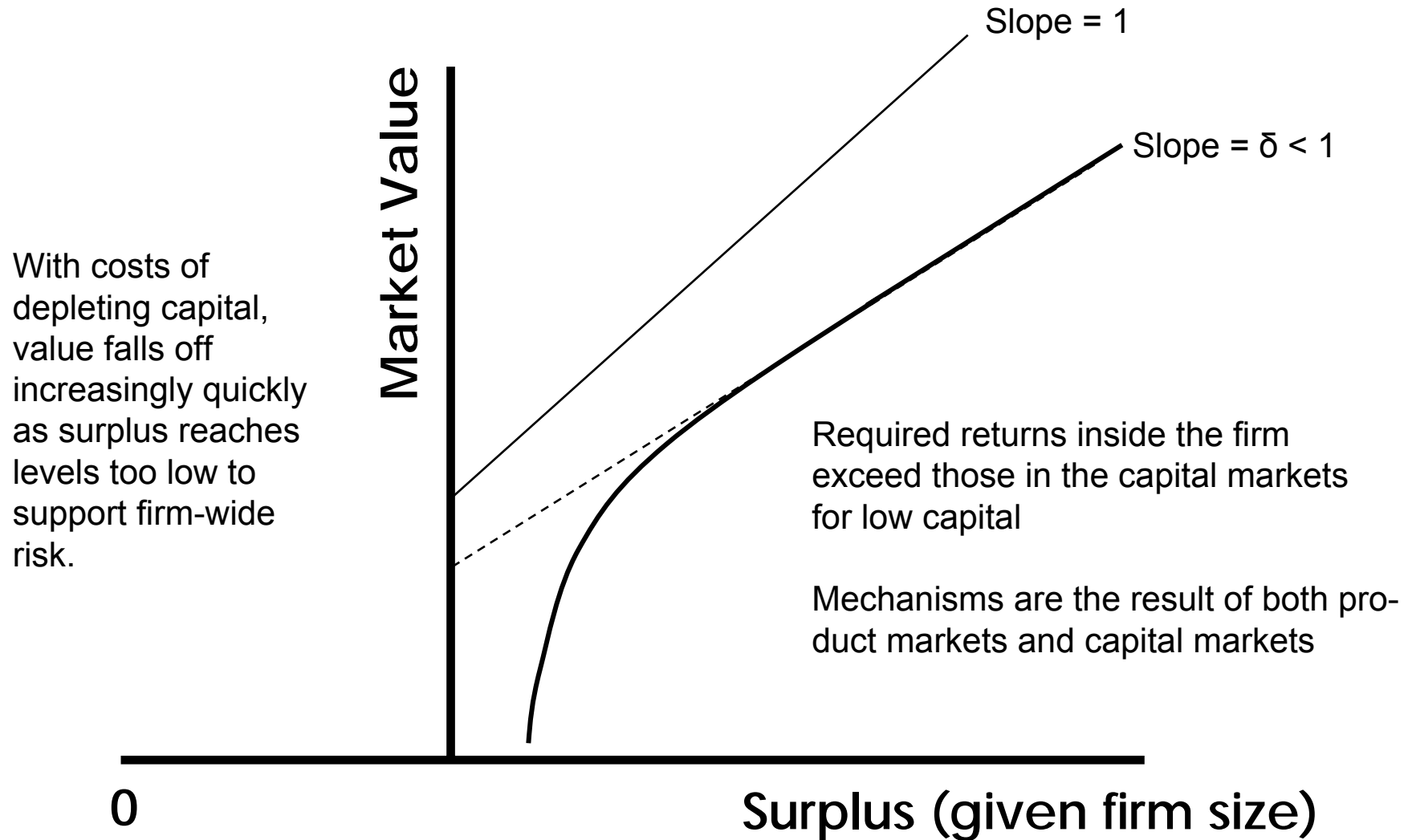
# A simple framework, step 1: Classical finance



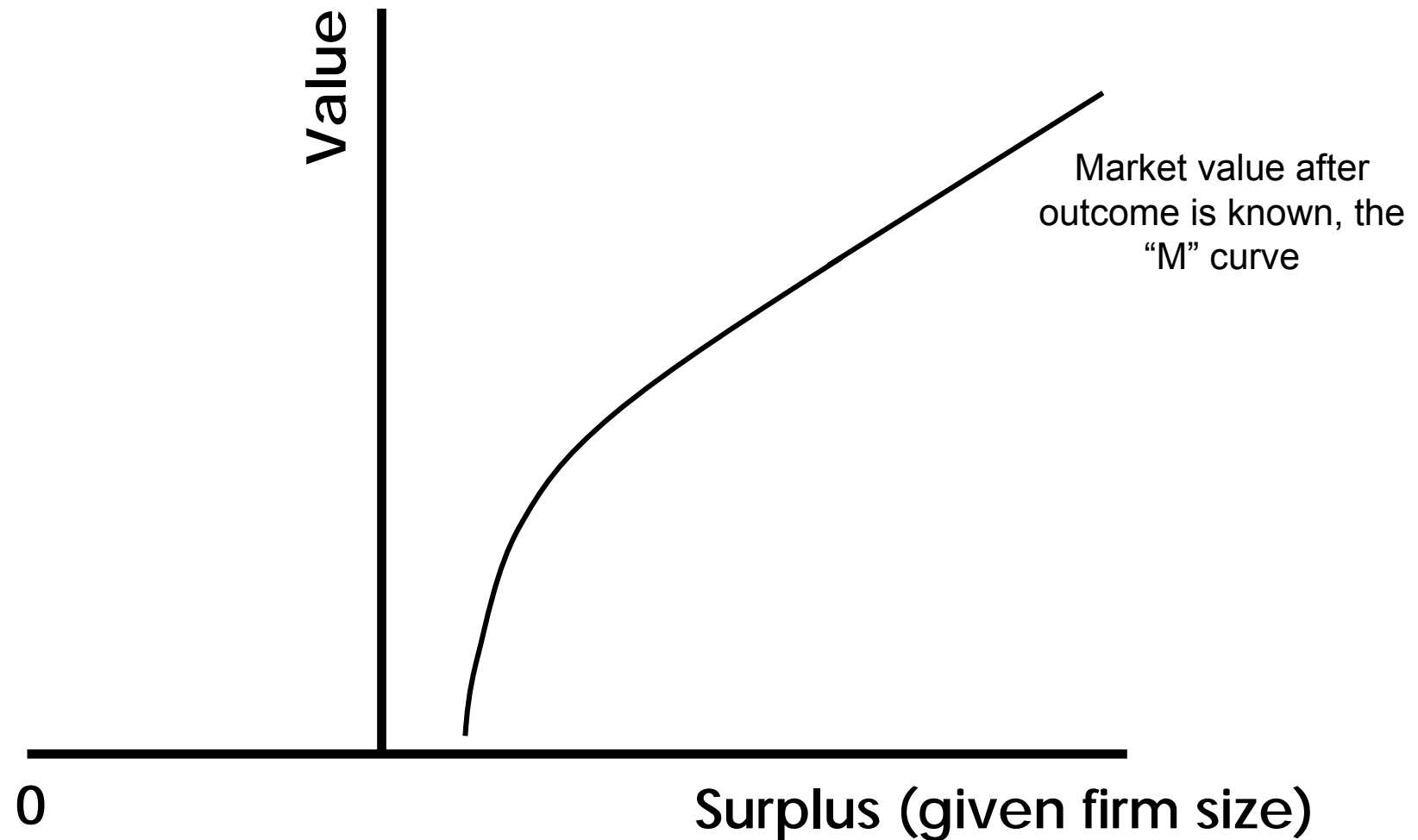
## A simple framework, step 2: Costs of hording capital



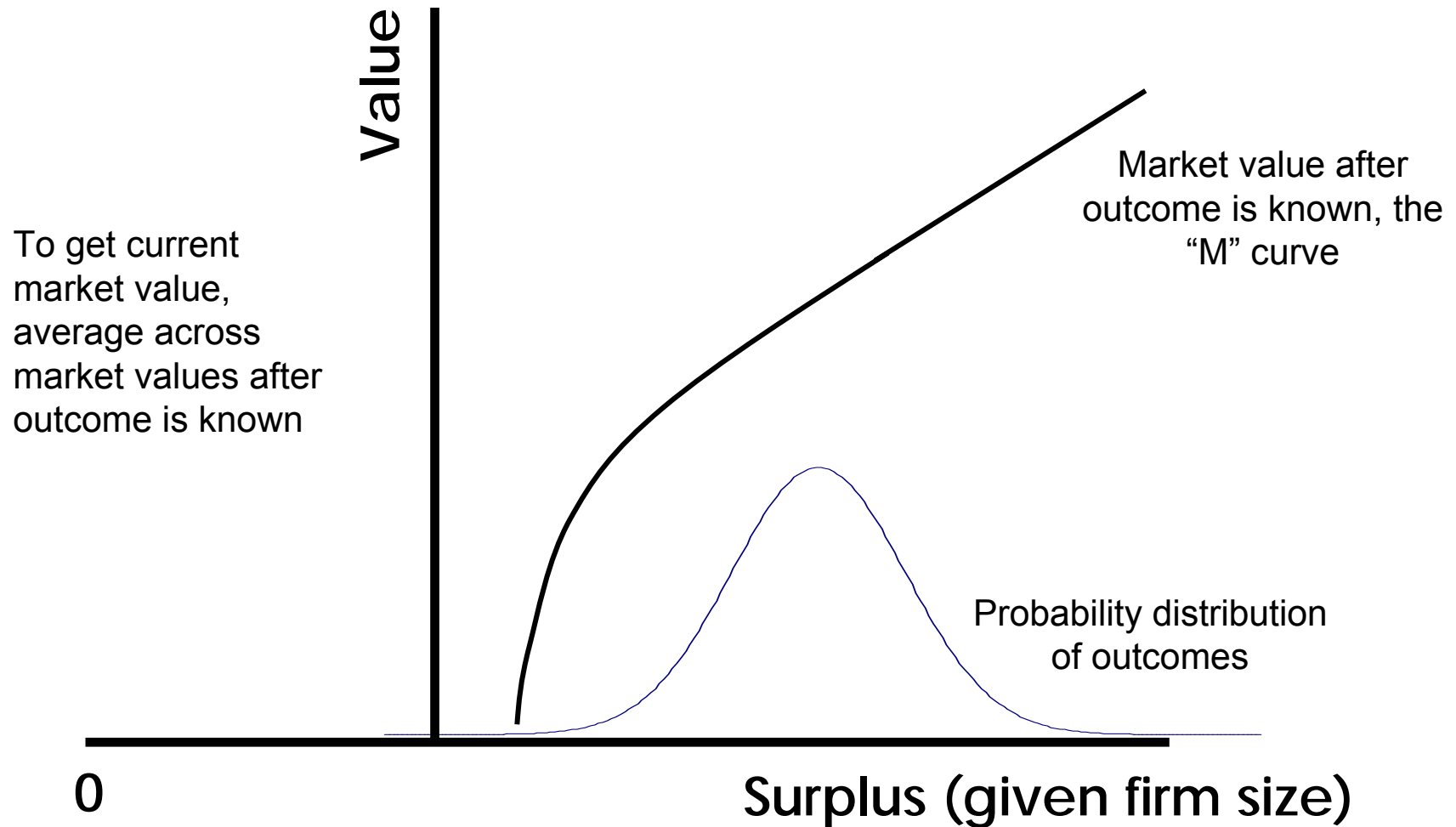
A simple framework, step 3:  
Costs of depleting and hoarding capital



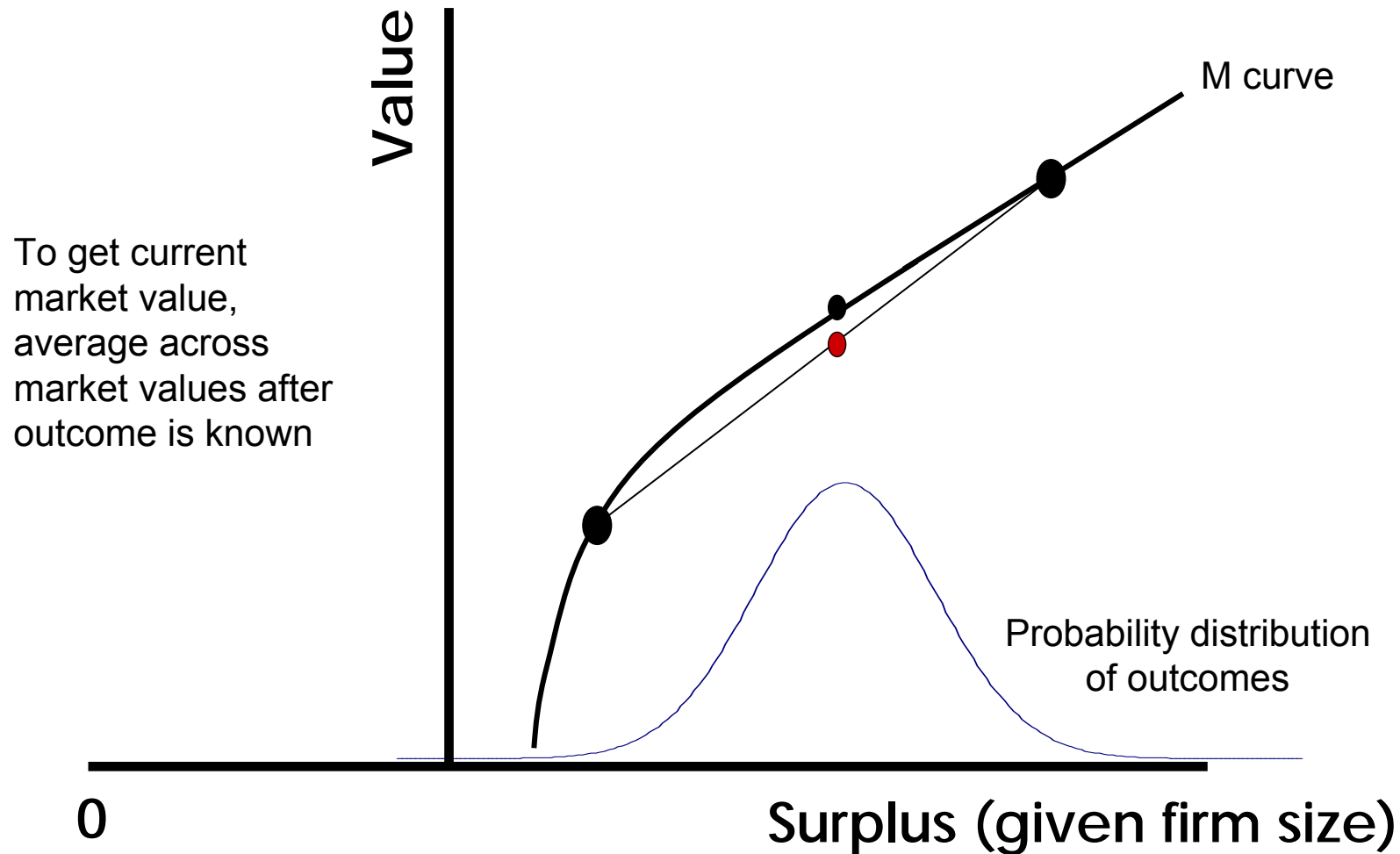
A simple framework, step 4:  
Market value before vs. after risk outcome



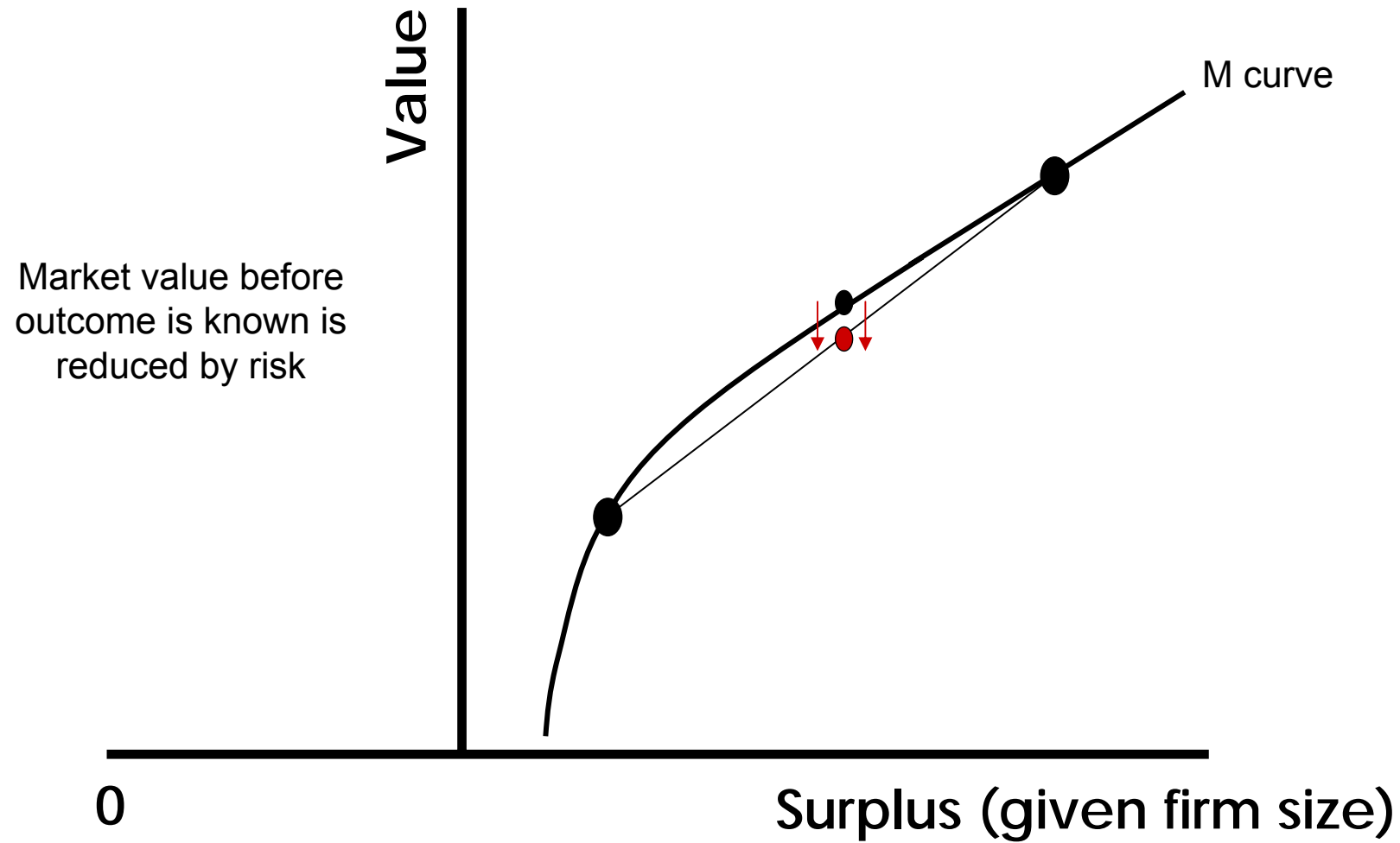
A simple framework, step 4:  
Market value before vs. after risk outcome



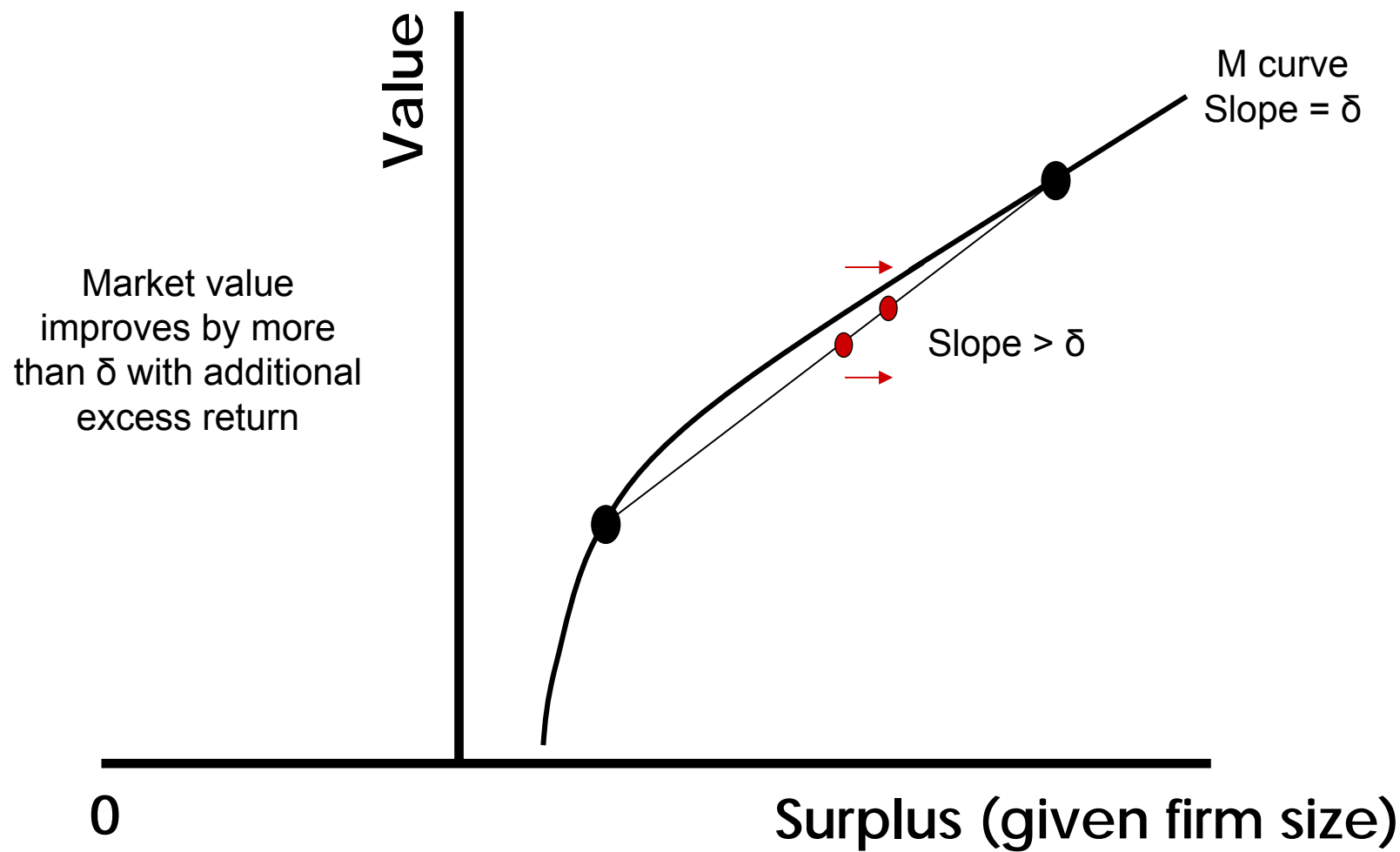
A simple framework, step 4:  
Market value before vs. after risk outcome



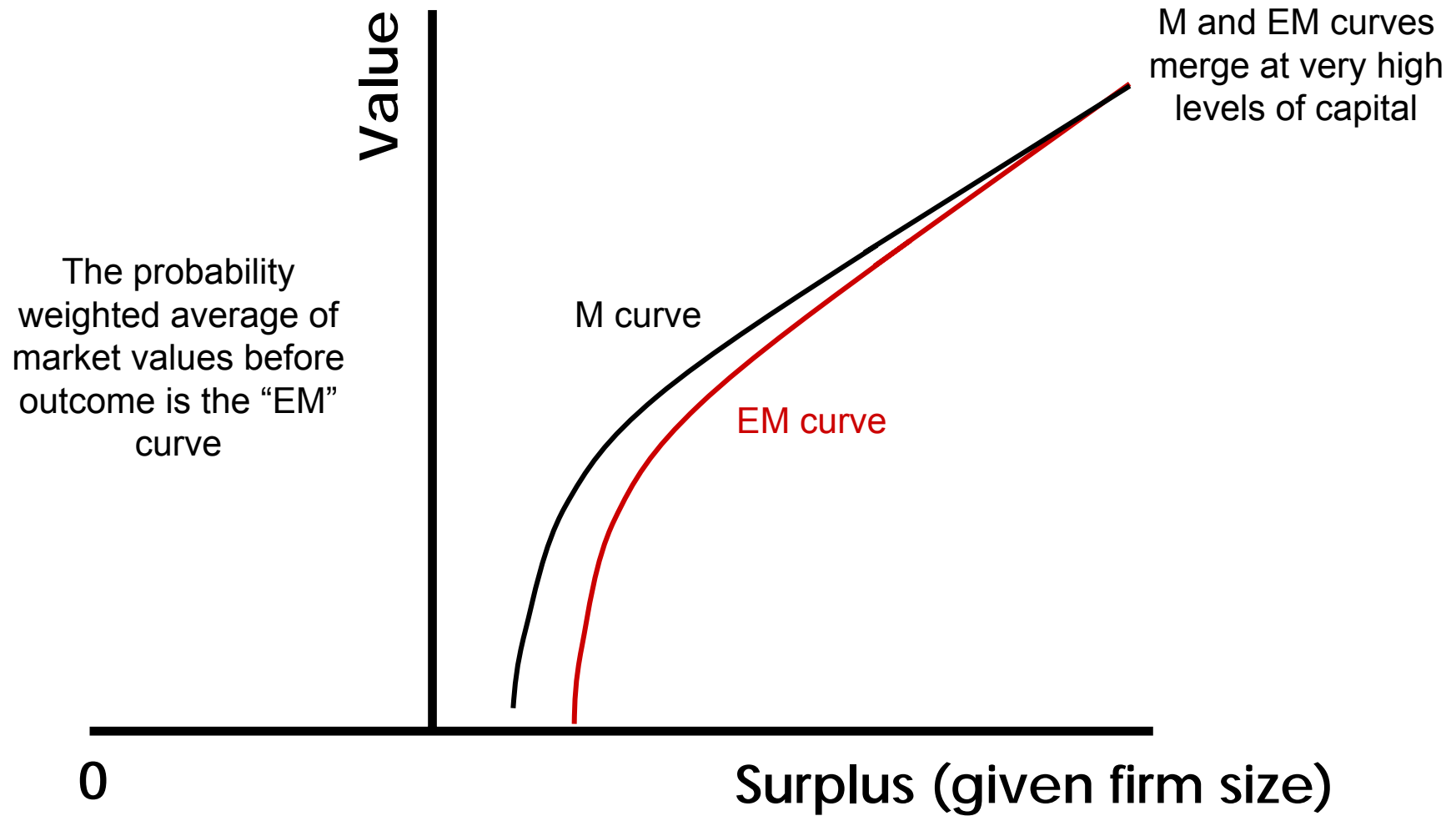
# A simple framework, step 5: Properties of market value



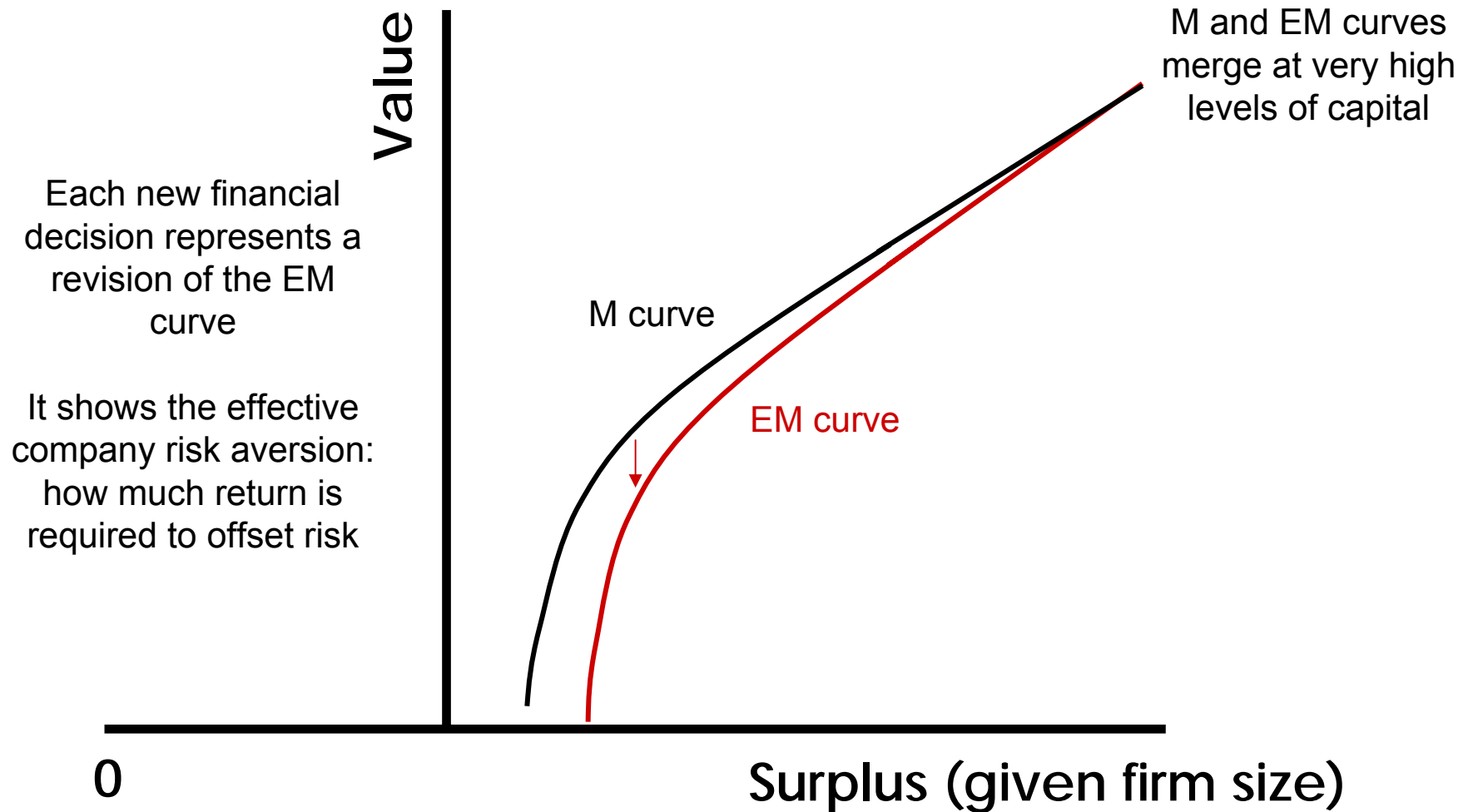
A simple framework, step 5:  
Market value *before* outcome is known



A simple framework, step 5:  
Market value *before* outcome is known

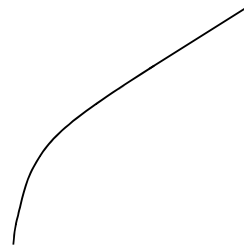


A simple framework, step 5:  
Market value *before* outcome is known

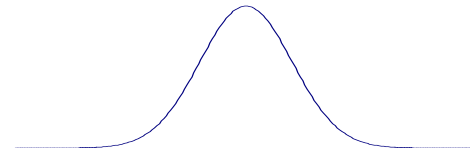


## The framework's most general insight

If we know the M curve



and the probability distribution of outcomes



we can determine the EM curve



Using these, we can determine how market value is affected by a wide variety of changes in firm-wide risk and return

## If the risk distributions are normal, more specific insights can be derived analytically...

- Required returns on incremental risks are driven by covariance with:
  - Standard market factor(s)
  - Internal firm-wide risks
  - Internal skewed risks
- The latter two influence  $\lambda$  and determine the direction of shift of the EM curve
- Optimal allocations to risk positions are also driven by three factors:
  - The minimum-variance allocation
  - The excess risk-adjusted return removing standard market factors
  - The skewness-adjusted covariance with existing exposures
- These determine the magnitude of shift of the EM curve
- Optimal amount of internal capital
  - Equates the marginal inefficiency of hoarding capital with the marginal costs from consumers and investors of depleting capital
- This determines movement along the EM curve

If the risk distributions are normal, these insights can be expressed in analytic terms...

- Incremental required returns on individual risk positions are driven by a three factor model, where the factors are: a) standard market-wide factors (e.g., CAPM); and b) internal factors that measure the impact of the incremental risk on insurer capital:

Insurer's required return on a position

Price and quantity of systematic risk in the position

$F$ : sensitivity of customers to firm-wide risk

$G$ : sensitivity of investors to firm-wide risk

$\tilde{G}$ : sensitivity to firm-wide risk skewness

$$\mu_{N,j} = r_f + \beta \text{cov}(M, \varepsilon_{N,j}^C) + (F + G) \text{cov}(w, \varepsilon_{N,j}^I) + \tilde{G} \text{cov}(\varepsilon_P^I, \varepsilon_{N,j}^I)$$

External CAPM premium above riskfree rate

Internal premium for covariance with firm-wide risk

Internal premium for covariance with firm-wide skewed risks

If the risk distributions are normal, these insights can be expressed in analytic terms...

- The optimal amount to hold of an individual risk positions is also driven by three factors: a) the minimum-variance risk allocation; b) the excess risk-adjusted return; and c) the skewness-adjusted covariance with existing exposures:

$$\begin{array}{cccc}
 \begin{array}{c} \text{Optimal} \\ \text{amount} \\ \text{of} \\ \text{a position} \\ \downarrow \\ n_j^* \end{array} & \begin{array}{c} \text{Hedge out} \\ \text{preexisting} \\ \text{exposure} \\ \downarrow \end{array} & \begin{array}{c} \text{Tilt toward} \\ \text{exposures that} \\ \text{outperform} \\ \downarrow \end{array} & \begin{array}{c} \text{Avoid risks that} \\ \text{overly} \\ \text{accentuate} \\ \text{extreme losses} \\ \downarrow \end{array} \\
 \left( \frac{-\text{cov}(w_j, \varepsilon_{N,j}^I)}{\text{var}(\varepsilon_{N,j}^I)} \right) + \left( \frac{1}{F+G} \right) \left( \frac{\mu_{N,j} - \gamma \text{cov}(\varepsilon_{N,j}^C, M)}{\text{var}(\varepsilon_{N,j}^I)} \right) - \left( \frac{\tilde{G}}{F+G} \right) \left( \frac{\text{cov}(\varepsilon_p^I, \varepsilon_{N,j}^I)}{\text{var}(\varepsilon_{N,j}^I)} \right) & & & \\
 \underbrace{\hspace{10em}} & \underbrace{\hspace{5em}} & \underbrace{\hspace{10em}} & \underbrace{\hspace{5em}} \quad \underbrace{\hspace{5em}} \\
 \begin{array}{c} \text{Amount of risk} \\ \text{in the minimum-} \\ \text{variance} \\ \text{portfolio} \end{array} & \begin{array}{c} \text{firm risk} \\ \text{tolerance} \end{array} & \begin{array}{c} \text{Excess risk} \\ \text{adjusted excess} \\ \text{return} \end{array} & \begin{array}{c} \text{Skewness} \\ \text{importance} \\ \text{times firm} \\ \text{tolerance} \end{array} & \begin{array}{c} \text{Skewness-} \\ \text{adjusted} \\ \text{covariance with} \\ \text{pre-existing} \\ \text{exposures} \end{array}
 \end{array}$$

# Some Empirical Evidence

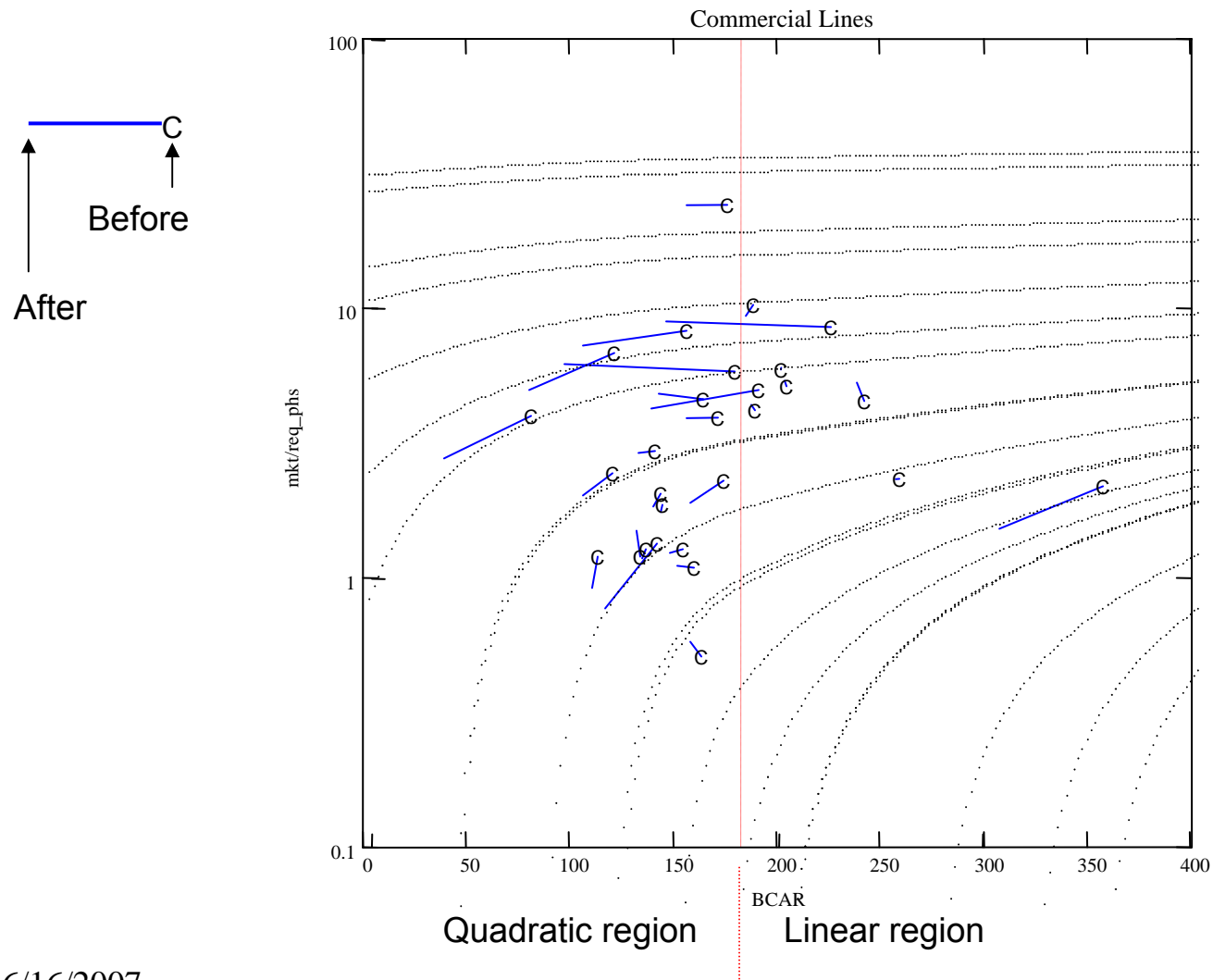
## Event Study Estimating the M curve

- Event Study across firms
  - Examines the stock price response of 31 publicly traded (re)insurers to 9/11 event, taking into account their size (policy holder surplus), pre-existing financial state (BCAR), and expected event losses formulated at the time.
    - Key hypothesis is that market price will decline by more than the expected loss, and more so for financially weaker firms.
    - Empirical specification uses the functional form:

$$\begin{array}{ccc}
 \boxed{\text{Market Loss}} & & \boxed{\text{Event Loss}} \\
 \swarrow & & \searrow \\
 M = f(L, B) + g(L, B) \cdot E & & \\
 \swarrow \quad \searrow & & \swarrow \quad \searrow \\
 \boxed{\text{Line of Business}} & & \boxed{\text{BCAR}}
 \end{array}$$

- Where the  $f$  and  $g$  functions are further simplified to be linear
- Key is coefficient  $E \times B g_2 = -0.02 < 0$ . It measures the rate at which sensitivity to loss changes with financial strength and determines the curvature of the M curve
- Integrate out the solution to transform returns into market value

# Intuition for Estimation: Data Overlaid to Applications Model



## Some Empirical Evidence Event Study Estimating the M curve

- Excess, risk-adjusted returns 1995-2001 on a panel of insurers are decreasing in the realized volatility of company earnings

**Coefficients<sup>a</sup>**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-9.31E-04	.003		-.346	.732
	MeanROE	1.835E-03	.001	.423	2.624	.014
	LNSTDROE	-2.61E-03	.001	-.334	-2.068	.048

a. Dependent Variable: Alpha

Controlling for company rating makes these results stronger

## Some Empirical Evidence also from 9/11

- Event losses from September 11, 2001 had a more negative impact on the market value of more-poorly-rated insurance firms

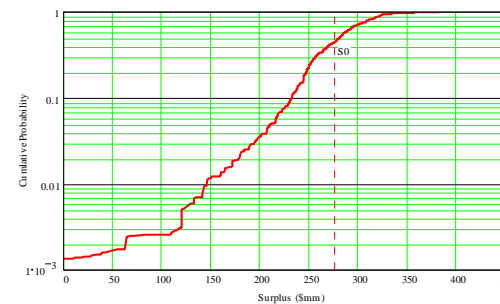
Table 4: Cumulative Average Abnormal Returns (CAAR) By Rating				
AmBest Rating	N	Days (0,1)	Days (0,4)	Days (5,30)
A++	6	-2.95	-2.62	7.80
A+	17	-6.74	-8.38	9.30
A	12	-3.37	-7.05	-0.88
A-	3	-2.06	-5.51	-8.75
Not Rated	5	-3.97	-7.29	9.18

From Cummins and Lewis, 2002, “Catastrophic events, parameter uncertainty, and the breakdown of implicit long-term contracting in the insurance market

# Calibrating the theory to the “Picky” Insurance Company

- An average company
  - Net Written Premiums = \$515 million
  - Policyholder Surplus = \$276 million
  - A+ Best’s rating, with Capital Adequacy Rating (BCAR) of 180
    - Required Surplus = \$153 million
  - Market Capitalization = \$340 million
    - 1.2 x policyholder surplus; 2.2 x required surplus
  - Underwriting book exposure (e.g., cat):
    - 100% combined ratio, expected loss = 0
    -

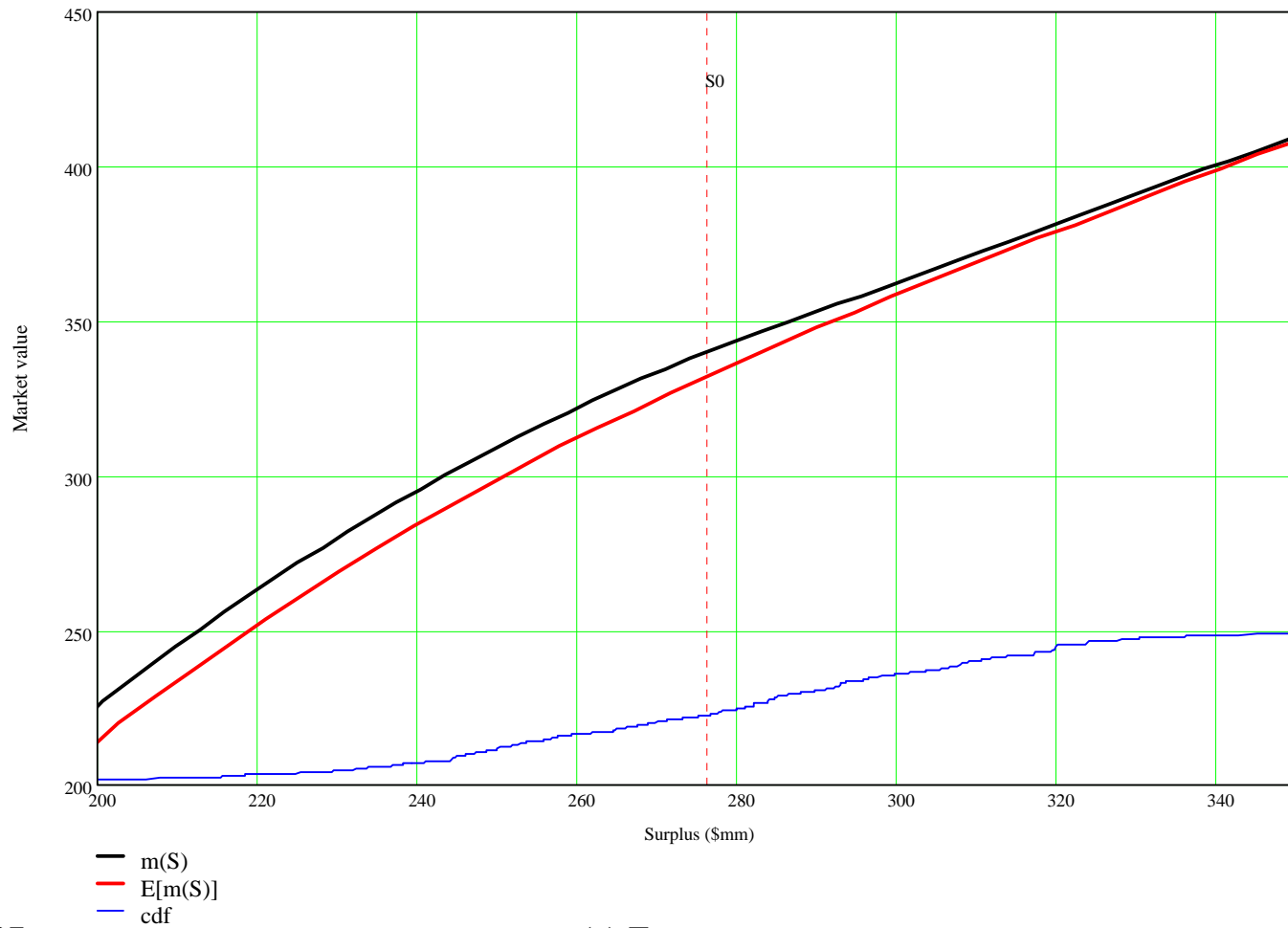
Loss Profile	Value	Surplus
1/500	\$213	77%
1/200	\$156	56%
1/100	\$131	47%
1/50	\$98	35%
1/20	\$65	23%



- An average goal: maximize market value

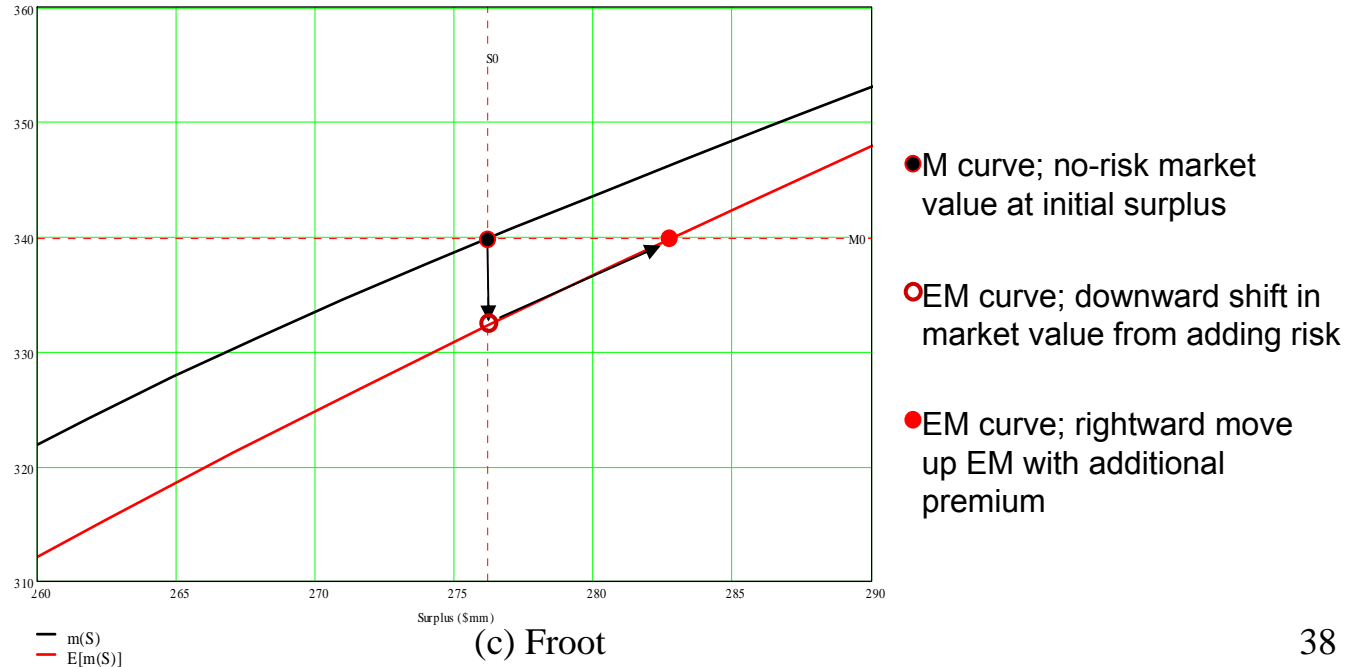
# The Picky Insurance Company

## Closeup of the M and EM curves



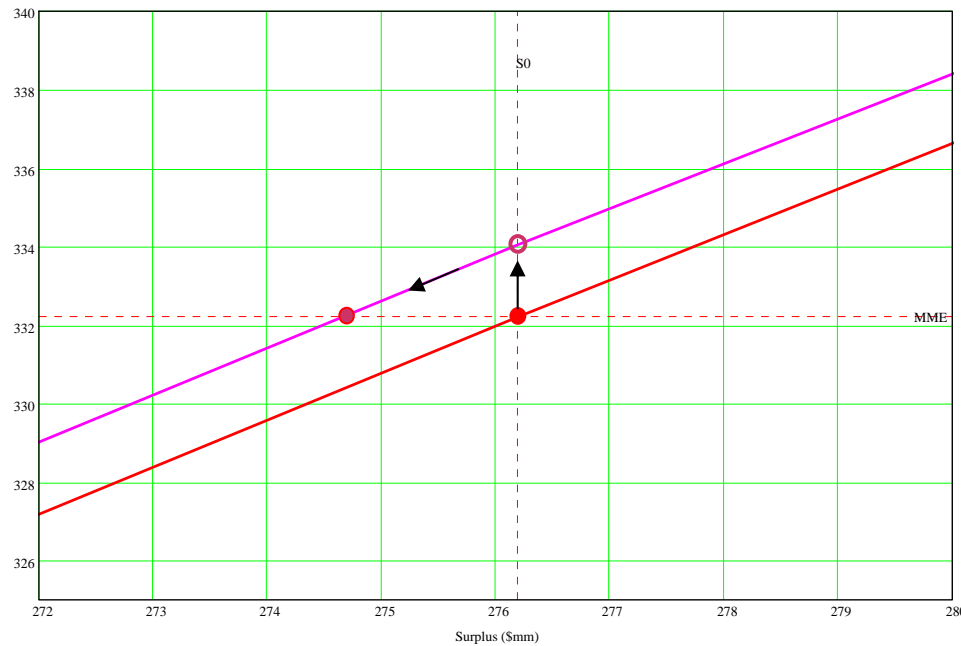
# Using the M Curve to Evaluate Financial Policies: Underwriting breakeven CR

- Profitability
  - At what CR do shareholders breakeven underwriting this book?
- Answer:
  - The cost of this risk in the equity market is \$7.7 million
  - \$6.6 million in additional premium fully offsets the cost
  - Since premiums were \$515 million, this translates to a required CR of 98.7%



# Using the M Curve to Evaluate Financial Policies: Value of Reinsurance (35 XS 85)

- Reinsurance
  - How valuable to shareholders is the XOL layer and what is their breakeven ROL?
    - 35 XS 85 with 2.5% ROL (premium = \$0.88) and expected loss 1.9% (\$0.66)
- Answer:
  - At ROL = 2.5% (0%), the layer is worth \$0.79 (\$1.81), or 2.3% (5.2%) of limit
  - Cover breaks even if ROL = 4.4%



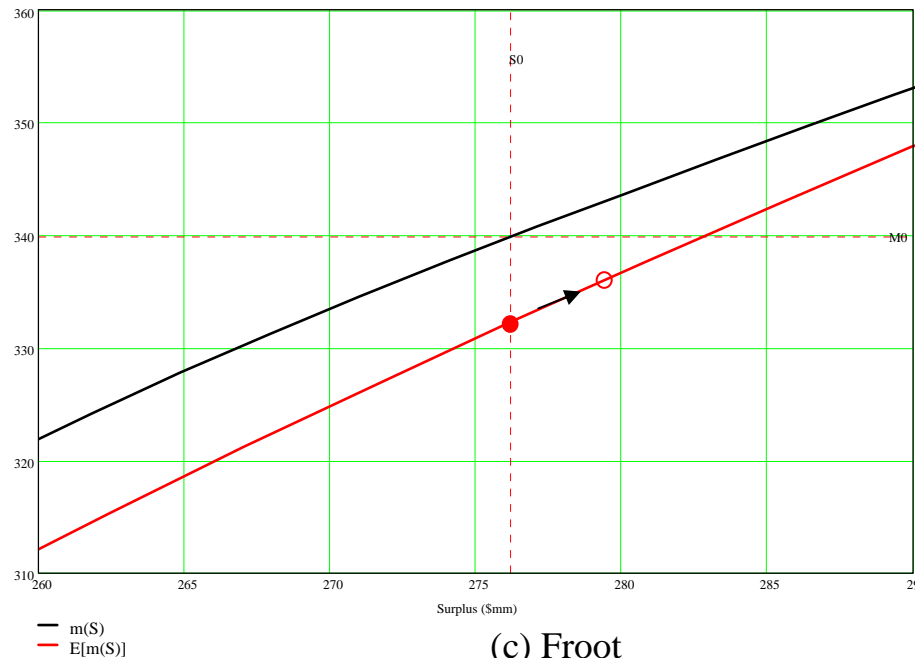
- EM curve; bare initial book, no reinsurance
- Reinsurance-adjusted EM curve; upward shift in value from removing risk
- Reinsurance-adjusted EM curve; leftward move down adjusted EM curve to reflect 4.4% reinsurance premium

—  $E[m(S)]$  bare  
—  $E[m(S)]$  r/i

(c) Froot

# Using the M Curve to Evaluate Financial Policies: The Price of Equity Issuance

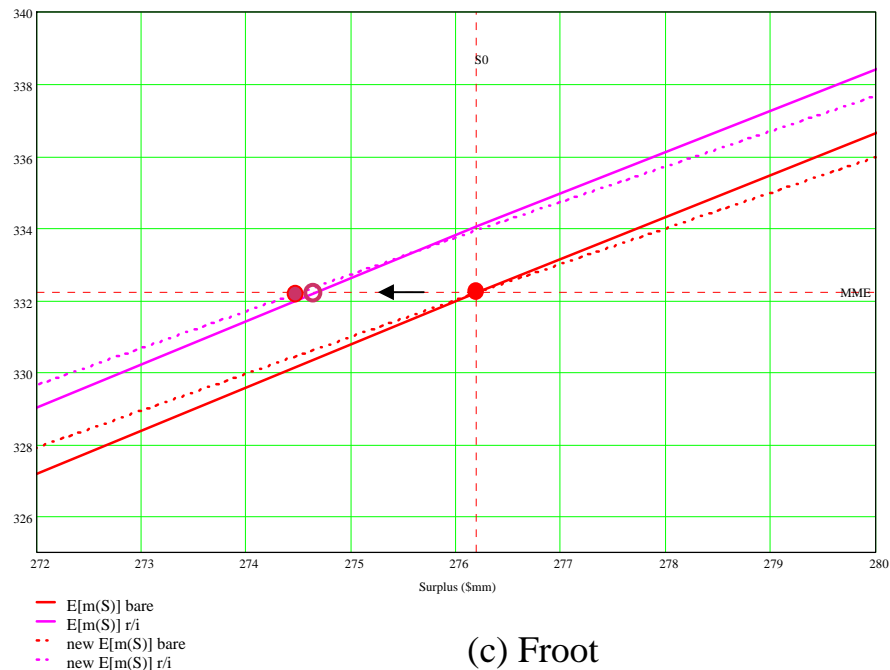
- Capital adequacy
  - If Picky instead pursued an equity issue equal to 1% of outstanding shares, would its market value be affected? By how much?
- Answer:
  - Increasing surplus by \$3.40 translates to \$3.96 market increase
    - Represents value added of \$0.56 or 16bp of market value



- EM curve; bare initial book; no reinsurance
- EM curve; rightward movement along curve to reflect added capital

# Using the M Curve to Evaluate Financial Policies: The Value of Equity Issuance at a Known Issue Price

- Capital adequacy
  - If Picky can get 99% of the current price in the equity offering, below what ROL will shareholders still prefer the reinsurance?
- Answer:
  - Using Picky's assumed issue price, reinsurance adds value if  $ROL < 4.9\%$

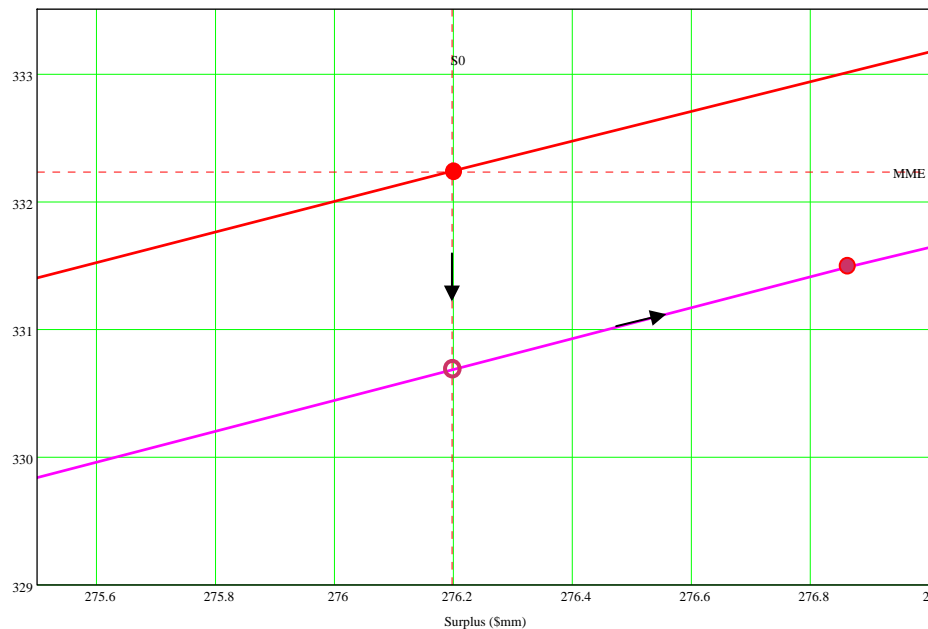


- EM curve; bare initial book, no reinsurance
- Reinsurance-adjusted EM curve; upward shift in value from removing risk
- EM curve adjusted for reinsurance and equity issue price; leftward move of reinsurance breakeven to 4.9%

# Using the M Curve to Evaluate Financial Policies: Valuing the Acquisition of Additional Business

- Underwriting acquisition
  - What is Picky's breakeven price to acquire an additional underwriting book, identical at 10% of the size of the first with a 98.7% CR, in an all-stock transaction?
- Answer:
  - The new book has an actuarial profit of \$0.66 million
  - Shareholder value would decrease \$0.75 after acquisition

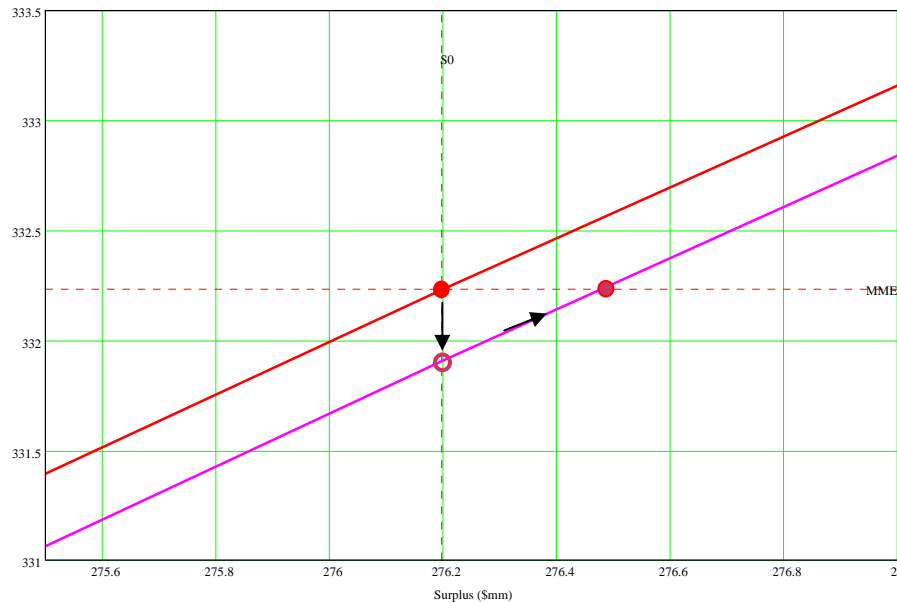
Combined Ratio	Actuarial Profit	Value Added
0.970	1.54	0.30
0.987	0.66	-0.75
1.000	0.00	-1.54



- EM curve; bare initial book, no reinsurance
- EM curve adjusted for additional book; downward shift in value from adding risk
- EM curve adjusted for additional book; rightward move up curve to reflect \$0.66 actuarial profit

# Using the M Curve to Evaluate Financial Policies: Value of Holding Risky Investment Assets

- Asset management policy
  - By how much would Picky’s investment team need to outperform to add value when allocating 20% of surplus to a diversified basket of equities?
- Answer:
  - Market value falls \$0.32 on investment of \$55.2 million
  - Outperformance of 58 bp fully offsets this



- EM curve; bare initial book, no reinsurance
- Equity-risk-adjusted EM curve; downward shift in value from shifting 20% surplus to equity
- Equity-risk-adjusted EM curve; rightward move up adjusted EM curve to reflect 58 bp out-performance

## Summary

- The framework (Froot, 2005) suggests how to translate financial policies into capital market value.
- Based on evidence that value is lost when financial strength suffers
- Does this suggest different mechanisms will be better?
  - Cat bonds and other insurance-linked securities (ILS)
  - Reduction in managerial discretion over capital

# New forms of intermediation are growing...

Corporate equity funds

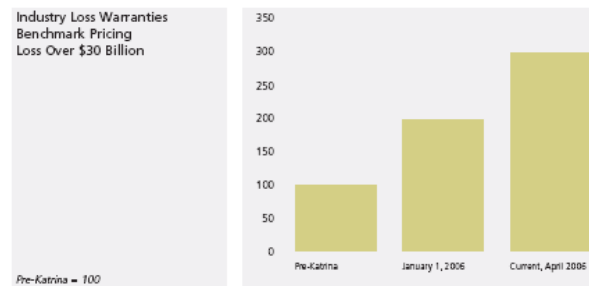


“Closed-end” Sidecars

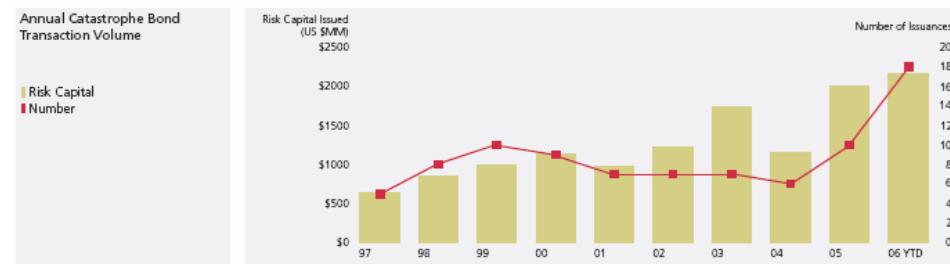
SIDECAR ARRANGEMENTS 2005-2006

SIDECAR ARRANGEMENTS 2005/2006	SPONSOR
Baypoint Re Ltd.	Harbor Point
Cyrus Reinsurance Ltd.	XL Capital, Highfields Capital
Flatiron Re Ltd.	Arch Capital, Goldman Sachs
Helicon	White Mountains
Petrel Re Ltd.	Validus, First Reserve Corp
Rockridge Re	West End Capital, Montpelier
Starbound Re	Ren Re

Industry-Loss Warranties



Cat bond issuance and holdings



6/16/2007

(c) Froot

45