Institute and Faculty of Actuaries

FINANCIAL GUARD

Economics and Modern Finance: Believe it or not.

Matt Modisett, PhD, FIA, ASA,MMA

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19 June 2014

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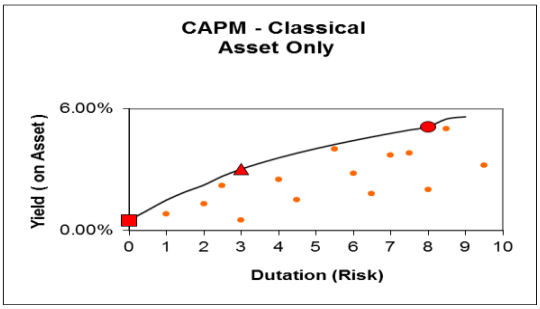
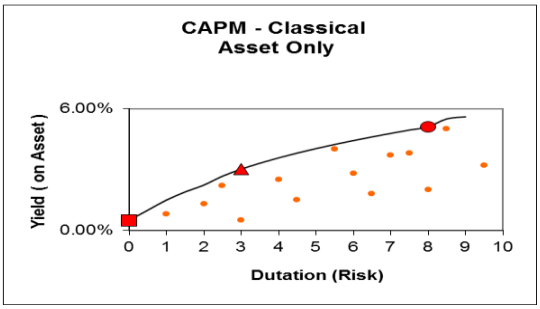


Capital Asset Pricing Model (CAPM)

Harry Markowitz



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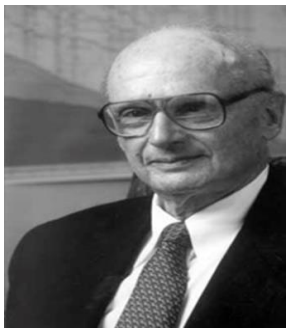
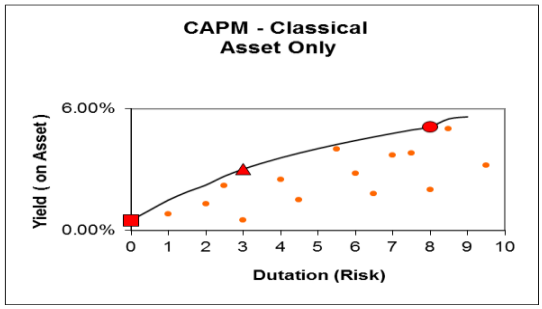


Harry Markowitz

Tip 1: Risk ≠ Return

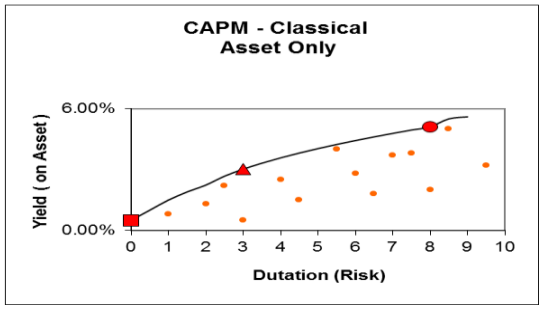
(Only on the efficient Frontier does Risk = Return)



Capital Asset Pricing Model (CAPM)

Example:

Consider Risk to be interest rate risk.
Risk and return increase with duration.



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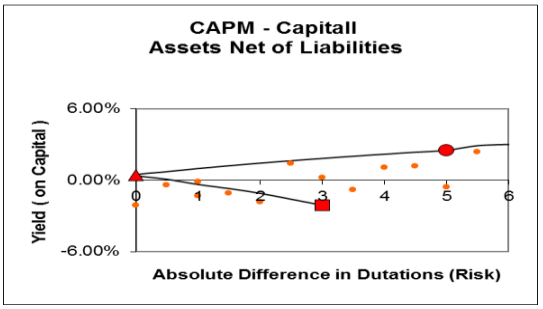

Capital **ONLY** Pricing Model (CAPM)

Example:
Risk dependent on **duration matching** of assets and liabilities.

Notice asset ■ has fallen off Efficient Frontier

Conclusions from ALM view of CAPM

- Risk is **NOT** a characteristic of assets.
- Risk is in the eye of the beholder.
  - Different market participants view asset risks differently.
  - Heterogeneous market participants
- There is no universal (homogeneous) view of value.

- Different views of risk lead to different bids in the market.
  - This is the cause of price fluctuations.

- In fact, markets are dependent of different views of value. If all market players had the same view, why transact?

Examples that Risk depends of View

- UK bonds “risk-free” to UK investors, not US investors.

- Stocks risk-free to unit-linked stock funds, but not to annuity writers.

- Solvency II, each insurer makes its own internal model.

Example of Model Bias

- Are Markets Efficient?
- How efficient are Markets? (Weak, Strong, Very Strong)

“Efficient markets” is a nonsensical idea. Risk depends on the beholder not the asset.

Example of Model Bias (2)

- Are Markets Efficient?
- How efficient are Markets? (Weak, Strong, Very Strong)

These questions are misleading. They assume a consensus of price that does not exist.

Typical Efficient Market Question:
“Is all news reflected in **the** market price?”

The “**the**” assumes a single market price, a consensus that does not exist.

Reformulate Market Questions

Tip 2: Assume Heterogeneous markets, not homogeneous.

Questions:

"What is the range of market opinions of price."

"What segments of market players are there?"

"Who would buy this asset now?
"When might currently inactive market players become active?"

"How do different players view news?"

"What is the range of values at quarter end?"

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Reformulate Market Questions

Risk ≠ Return

Heterogeneous Market Players

No Consensus on Price

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Myron Scholes

Fischer Black

Robert Merton

Black-Scholes-Merton Option Pricing Model(s)

Myron Scholes

1997
Won Nobel Prize

Robert Merton

Black-Scholes-Merton Option Pricing Model(s)

1997
Won Nobel Prize

1998
Long-Term Capital Management
Loses $4.6 Billion
Federal Reserve Bailout

Myron Scholes

Robert Merton

Black-Scholes-Merton Option Pricing Model(s)

What is used today?

Black-Scholes Option Price used today.

More generally, option pricing theory underpins insurance Market Consistent Models.

Reliance on “Tail Correlations” is cited as a reason for fall of Long-Term Capital Management.

Tail correlations discussed in Solvency II implementations, (though not academically supported).

Tip 3: Black-Scholes option pricing theory is wrong

(but still useful).

B.S.

Not a problem that B.S is wrong.

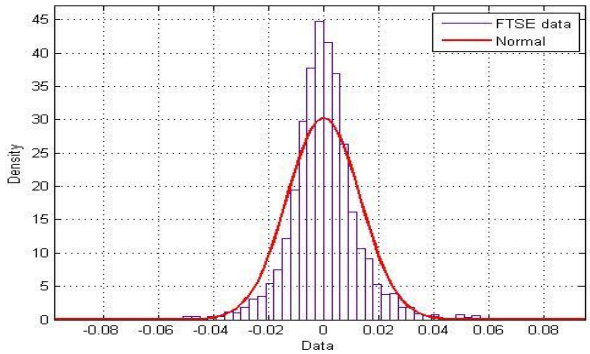
It is only a pricing convention, like yield.

Pricing models are actually fitting models.

Solve for yield.

Solve for volatility.

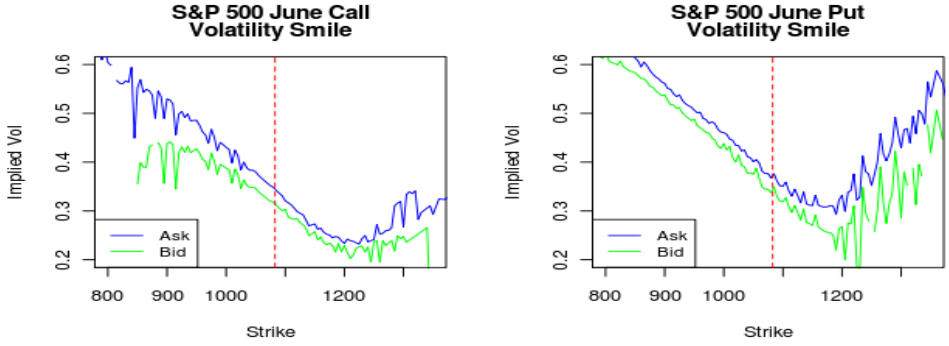
B.S. – Log-normal Distribution



Black-Scholes theory says that stock prices move log-normally.
All statistical tests show distribution is not lognormal

Black-Scholes claim is not true. **So Black-Scholes is wrong.**

B.S. – Volatility Smile



Black-Scholes says the above lines should be horizontal.
Black-Scholes theory says that options that have all features the same but strike should have the same implied volatility.

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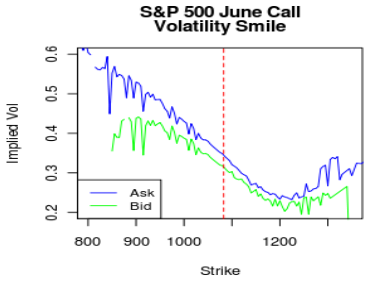

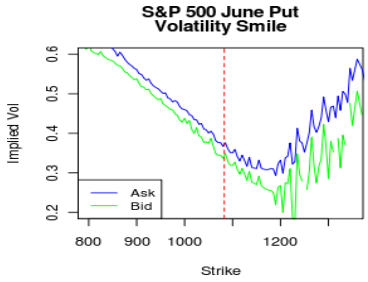

Theories to explain the Volatility Smile are ad hoc.

Efforts to incorporate jump, or stochastic volatility are in the end simply fitting exercises with questionable theory behind them. They have interesting math but not financial insight.

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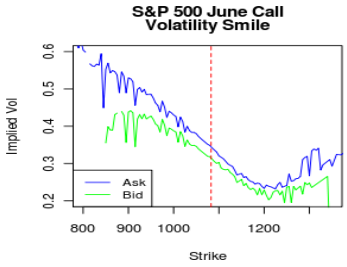
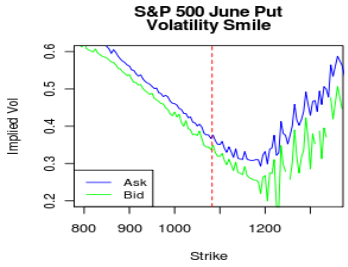
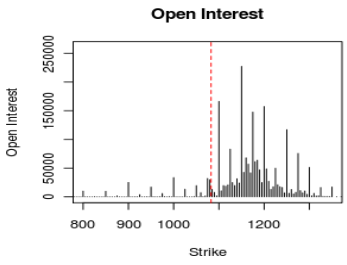
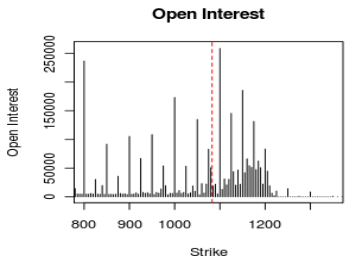
B.S. – Volatility Smile









Theories to explain the Volatility Smile are ad hoc.

Perhaps new explanatory variables are needed.

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B.S.

That yield, or volatility, can accommodate any price is **opposite to that which scientific theories do**.

Example: Feathers and rocks fall at different speeds.

If we solved for the force of gravity to explain any fall time, it is not science. It is fitting the data.

A more complicated model is necessary (air resistance).

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Tip 4: Do not ascribe too much meaning to model parameters
(like volatility).

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Tip 3: Black-Scholes option pricing theory is wrong

(but still useful).

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ALM versus Capital Management

Tip 5: Asset-Liability Management models compare fruit to fruit, though they may not be apples.

Tip 6: You need more than Asset-Liability Management models to net economic value.

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ALM versus Capital Management

- ALM, in particular duration matching, is useful.
  - It employs risk-free rates in particular to discount liabilities.
- This does not mean discounting liabilities at risk-free is always right.
- The Valuation Interest Rate (VIR) or Matching Adjustment is about using a spread over risk-free.
  - Major issue of Solvency II

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ALM versus Capital Management

- **What's the difference?**

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ALM versus Capital Management

- What's the difference?
- **ALM focuses on first derivatives:** $\frac{dV}{dr}$
  - **Matching first derivatives of assets to liabilities**
  - **Assuming a spread does not change the duration significantly**

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ALM versus Capital Management

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  - **The spread over liabilities is crucial – potentially wiping out a company's capital**

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  - The spread over liabilities is crucial – potentially wiping out a company's capital
- **It is like EIOPA left off the constant of integration.**

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ALM versus Capital Management

- **Risk-free pricing vs Funding Rate**
  - **Risk-neutral vs Real World**
  - **EIOPA vs IFRS**
    - **Though EIOPA is giving way towards Market Adjustment**

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ALM versus Capital Management

- Risk-free pricing vs Funding Rate
  - Risk-neutral vs Real World
  - EIOPA vs IFRS
    - Though EIOPA is giving way towards Market Adjustment

- **Implications of spread on liabilities:**
  - **Two different durations**
    - **Derivative versus changes in risk-free rates,**
    - **Derivative versus changes in spreads over risk-free.**

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Kenneth Rogoff

This Time is Different
Governments
Regularly Default

Correlation between
Heavy Debt and
Economic Malaise
(Justifies Austerity)

Carmen Reinhart

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Kenneth Rogoff

Spreadsheet ERRORS

This Time is Different
Governments
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~~Correlation between Heavy Debt and Economic Malaise (Justifies Austerity)~~

Thomas Herndon

Carmen Reinhart

Spreadsheet ERRORS

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Kenneth Rogoff

This Time is Different

Governments Regularly Default

Carmen Reinhart

The implications for "risk-free" rates is the more profound modelling conclusion from Reinhart and Rogoff than the discussion of austerity.

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Risk-Free

Tip 7: There is no risk-free rate (or more than one).

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Risk-Free

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No risk-free rate:

- **Governments regularly are 10% in default, sometimes 30%.**
- **Even USA defaulted in 1930s when it changed the gold value from 1/20th to 1/35th of an ounce.**
- **PIIGS don't seem risk-free.**

Risk-Free

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More than one risk-free rate:

- **There are SWAPS and there are Governments rates, both assumed risk free.**
- **A well-diversified portfolio of corporates "should" default at a rate less than the spread.**

Risk-Free

- **A well-diversified portfolio of corporates "should" default at a rate less than the spread.**

True believers of risk-free rates jump on the probabilistic wording of the last sentence. They accuse the highly probable excess corporate spread of being "Not perfectly risk free".

However, with what we have seen, governmental rates are not risk-free.

Both governmental bonds and diversified corporate bonds portfolios have a chance of default comparable to the other.

Neither of these is so special as to deserve the title risk-free.

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Risk-Free

Tip 8: Risk-free is a pricing convention only.

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Risk-Free

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- **When a gov't seems impaired, it is considered separately, e.g. PIIGS.**
- **Imagine the difficulty of pricing corporate spreads if the base rate (gov't or SWAPS) had its own default assumption.**

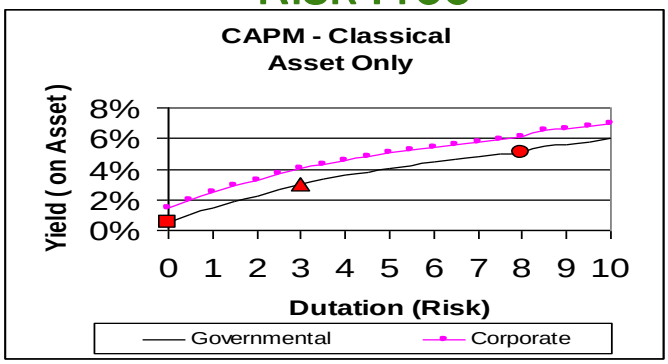
Risk-Free

Tip 8: Risk-free is a pricing convention only.

- When a gov't seems impaired, it is considered separately, e.g. PIIGS.
- Imagine the difficulty of pricing corporate spreads if the base rate (gov't or SWAPS) had its own default assumption.

Tip 8a: Risk-free does not mean it literally.

Risk-Free



Are government bonds just low yielding versions of corporate bonds?

The Larger Conflict

Tip 9: Actuarial science is the middle sibling between two quarrelling brothers:
Economics and Modern Finance theory.

Examples:

- Real world vs. Risk-neutral

- Option pricing:
  - Economics: prices driven by supply-demand
  - Modern Finance: supply-demand have no effect.

The Larger Conflict

Economics versus Modern Finance theory.

- Difficulty of measuring volatility
- Difficulty of measuring supply and demand

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The Larger Conflict

Economics versus Modern Finance theory.

- Difficulty of measuring volatility
- Difficulty of measuring supply and demand
  - Interestingly, traders measure supply and demand with order books.
- What about the 1-in-200 event necessary for capital requirements?

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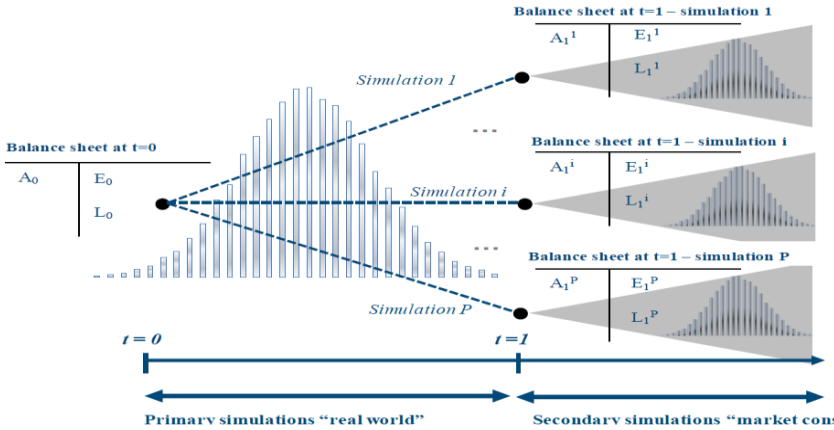
1-in-200 Paradigm mixes Real World and Risk-Neutral



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1-in-200 Paradigm
Don't believe the Answer (too much)

Tip 10: There is a lot of uncertainty in all our capital estimates.

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Extreme Events Working Party:

1-in-200 event for share prices:

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1-in-200 event for share prices: [-75%, -8%]

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Tip 10: There is a lot of uncertainty in all our capital estimates.

Extreme Events Working Party:

1-in-200 event for share prices: [-75%, -8%]

So, if we hold £100 million of share risk, our capital requirement is between:

£8 million and **£75 million**

1-in-200 Paradigm
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Tip 11: A 1-in-200 stress has a large confidence interval.

1-in-200 Paradigm
Don't believe the Answer (too much)

Tip 11: A 1-in-200 stress has a large confidence interval.

Tip 11a: Fixing a parameter does not reduce its uncertainty.

1-in-200 Paradigm: Don't Believe

Suppose we could rerun a 200-year history. What different answers for a 1-in-200 event would we get?

Experiment: Perform 50 experiments,

- Each experiment takes 200 samples from a T-distribution and keeps the worst.

What is the range of answers I got?

1-in-200 Paradigm: Don't Believe

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What is the range of answers I got?

DoF	Range of worst in 200 over 50 simulations
3	[-97%, -26%]
5	[-64%, -29%]
10	[-73%, -36%]
20	[-58%, -39%]
50	[-63%, -41%]

That's uncertainty!

(and we "knew" the distribution)

Uncertainty of Correlation

Example:

- Generate data set with 80 pairs of data points.
- Correlation is 25%. (Point estimate)

- 95%-confidence interval[1] of correlation is: **[3%, 45%]**

That's uncertainty.

[1] Using the Fischer Transform.

Uncertainty in Capital Requirements

	Required Capital
Best Estimate	299
Range when Single Parameter varied one at a time	(214, 420)
Range when parameters of Single Risk Factor Varied	(163, 449)
Range when Aggregation Parameters Varied	(273, 359)
Range when All parameters Varied	(105, 557)

Table: Summary of Uncertainty of Capital Requirements.
Example of Portfolio with 2 sub-portfolios.

That's uncertainty.

Capital requirements vary wildly for even modest changes in parameters.

"Uncertain" Tips

Tip 12: A 1-dimensional (stand alone) 1-in-200 stress could be doubled or halved within a 95% confidence interval.

Tip 13: Aggregation (to more dimensions) carries or amplifies uncertainty.

Tip 14: Know that the uncertainty of correlations is enormous. This has large effects on the final required capital.

- "Fixing" the correlation does not reduce its uncertainty.

Why bother too much with sampling error? Calibration?

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Profitable Embrace of Uncertainty

Embracing uncertainty is not just professional honesty.

It is a practical direction in modelling.

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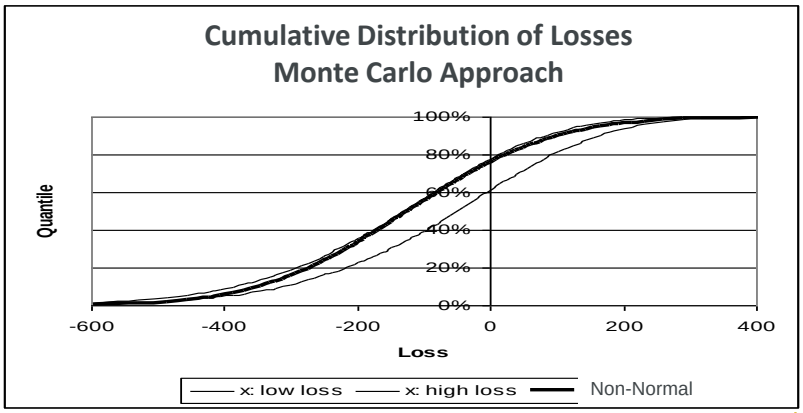
Quick Models – Single Distributions

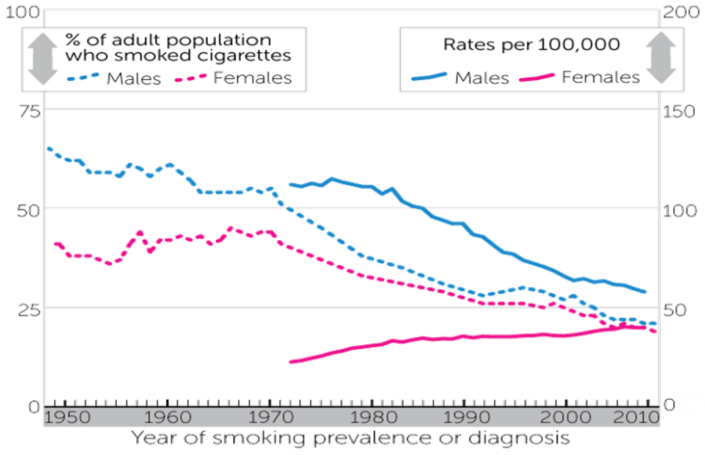
Tip 15: Considered confidence intervals of a distribution when fitting.



A non-normal distribution can fit between normal with confidence.

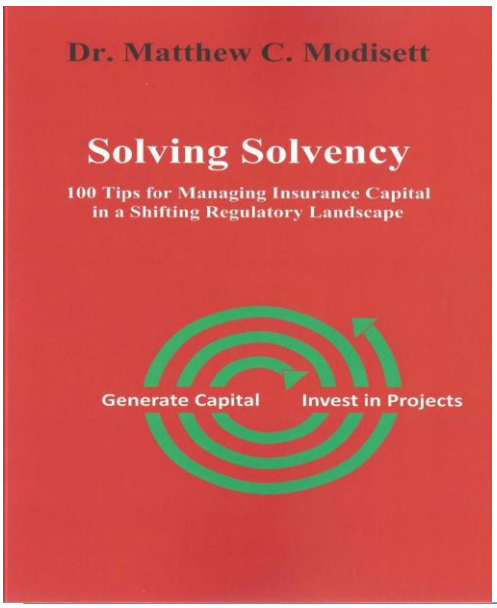
LUNG CANCER and SMOKING

- Cigarette Smoking Prevalence, and Age-Standardised Lung Cancer Incidence, by Sex, Great Britain 1948-2010



Summary

- Careful of assumptions
  - E.g. one-market price, risk-free
- Be very sceptical of calibrations:
  - Perform Lots of sensitivities to parameters
    - Particularly for correlations
  - Use Expert Judgement to override numbers.
- Just because a model has errors does not make it completely wrong or useless.



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Questions