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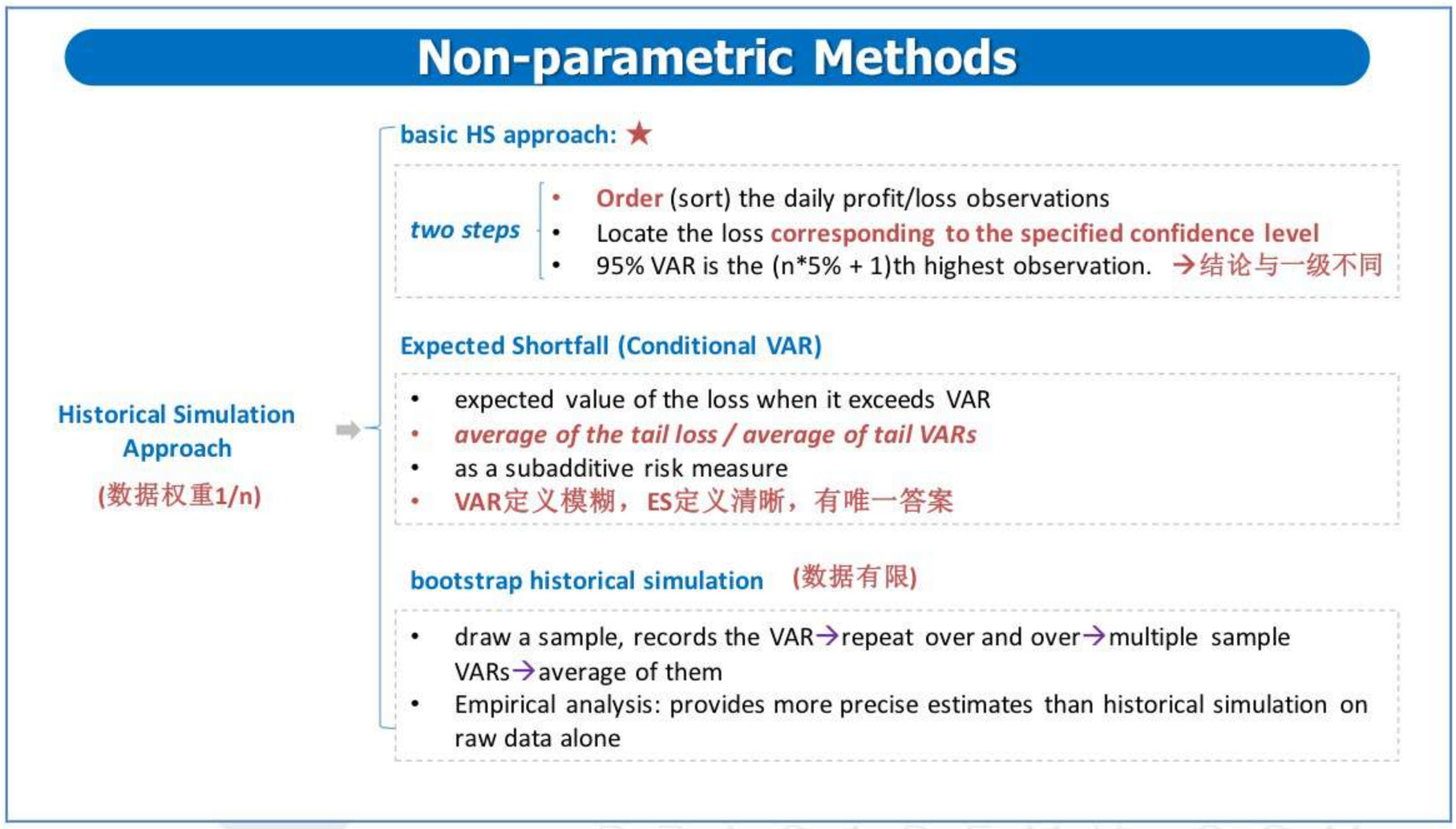
# Market Risk Measurement and Management

## 1 Parametric And Non-parametric Methods Of Estimation

### 1　Non-parametric Methods






**1.1** The VaR at a 95% confidence level is estimated to be 1.56 from historical simulation of 1,000 observations. Which of the following statements is most likely true?

A. The parametric assumption of normal returns is correct

B. The parametric assumption of lognormal returns is correct

C. The historical distribution has fatter tails than a normal distribution.

D. The historical distribution has thinner tails than a normal distribution.

***Answer: D***

**1.2** A risk analyst is comparing the use of parametric and non-parametric approaches for calculating VaR and is concerned about some of the characteristics present in the loss data. Which of the following distribution characteristics would make parametric approaches the favored method to use?

A. Skewness in the distribution

B. Fat tails in the distribution

C. Scarcity of high magnitude loss events

D. Heteroskedasticity in the distribution

***Answer: C***

Non-parametric approaches can accommodate fat tails, skewness, and any other non-normal features that can cause problems for parametric approaches. However, if the data period that is used in estimation includes few losses or losses with low magnitude, non-parametric methods will often produce risk measures that are too low. Hence parametric methods would be more appropriate in those situations.

**1.3** What is a key weakness of the value at risk (VaR) measure? VaR:

A. Does not consider the severity of losses in the tail of the returns distribution.

B. Is quite difficult to compute.

C. Is subadditive.

D. has an insufficient amount of backtesting data

***Answer: A***

VaR does not consider losses beyond the VaR threshold level.

**1.4** Over the following 10 trading days, the lowest portfolio return is -2.59%. Rounded to the nearest percent, what should the risk manager's result be for the updated 1-day 95% VaR? (Important)

A. 3%

B. 4%

C. 5%

D. 6%

***Answer: A***

**1.5** All of the following items are generally considered advantages of non-parametric estimation methods except:

A. Ability to accommodate skewed data.

B. Availability of data.

C. Use of historical data.

D. Little or no reliance on covariance matrices.

***Answer: C***

The use of historical data in non-parametric analysis is a disadvantage, not an advantage. If the estimation period was quiet (volatile) then the estimated risk measures may understate (overstate) the current risk level. Generally, the largest VaR cannot exceed the largest loss in the

historical period. On the other hand, the remaining choices are all considered advantages of non-parametric methods. For instance, the non-parametric nature of the analysis can accommodate skewed data, data points are readily available, and there is no requirement for estimates of covariance matrices.

## 2 Expected Shortfall

**2.1** After estimating the 99%, 1-day VaR of a bank's portfolio to be USD 1,484 using historical simulation with 1000 past trading days, you are concerned that the VaR measure is not providing enough information about tail losses. You decide to re-examine the simulation results and sort the simulated daily P&L from worst to best giving the following worst 15 scenarios:

| Scenario Rank | Daily P/L |
|---|---|
| 1 | USD -2,833 |
| 2 | USD -2,333 |
| 3 | USD -2,228 |
| 4 | USD -2,084 |
| 5 | USD -1,960 |
| 6 | USD -1,751 |
| 7 | USD -1,679 |
| 8 | USD -1,558 |
| 9 | USD -1,542 |
| 10 | USD -1,484 |
| 11 | USD -1,450 |
| 12 | USD -1,428 |
| 13 | USD -1,368 |
| 14 | USD -1,347 |
| 15 | USD -1,319 |

What is the 99%, 1-day expected shortfall of the portfolio?

A. USD 433

B. USD 1,285

C. USD 1,945

D. USD 2,833



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***Answer: C***

Expected Shortfall = Average of the worst 10 daily P&L= USD 1945

**2.2** A mutual fund has USD 50 billion in assets. The risk manager computes the daily VaR at various confidence levels as follows: (Practice Exam)

| **Confidence Level** | **VaR (USD)** |
|---|---|
| 95.5% | 787,000,000 |
| 96.0% | 800,000,000 |
| 96.5% | 835,000,000 |
| 97.0% | 865,000,000 |
| 97.5% | 895,000,000 |
| 98.0% | 931,000,000 |
| 98.5% | 979,000,000 |
| 99.0% | 1,042,000,000 |
| 99.5% | 1,139,000,000 |

What is the closest estimate of the daily expected shortfall at the 97.5% confidence level?

A. USD 821 million

B. USD 895 million

C. USD 919 million

D. USD 1023 million

***Answer: D***

An estimate of the expected shortfall can be obtained by taking the average of the VaRs for the various confidence levels that are greater than 97.5%.This leads to an estimate of USD 1,023,000,000.

**2.3** A large commercial bank is using VaR as its main risk measurement tool. Expected shortfall (ES) is suggested as a better alternative to use during market turmoil. What should be understood regarding VaR and ES before modifying current practices?

A. Despite being more complicated to calculate, ES is easier to backtest than VaR.

B. Relative to VaR, ES leads to more required economic capital for the same confidence level.

C. While VaR ensures that the estimate of portfolio risk is less than or equal to the sum of the risks of that portfolio's positions, ES does not.



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D. Both VaR and ES account for the severity of losses beyond the confidence threshold.

***Answer: B***

Expected shortfall is always greater than or equal to VaR for a given confidence level, since ES accounts for the severity of expected losses beyond a particular confidence level, while VaR measures the minimum expected loss at that confidence level. Therefore, ES would lead to a higher level of required economic capital than VaR for the same confidence level. In practice, however, regulators often correct for the difference between ES and VaR by lowering the required confidence level for banks using ES compared to those using VaR.

**2.4** The risk manager's best estimate of the 1-day 95% ES should be closest to the: (Important)

A. 1-day 90% VaR.

B. 1-day 95% VaR.

C. 1-day 97.5% VaR.

D. 1-day 99% VaR.

***Answer: C***

**2.5** Assume that an operational process has a 5% probability of creating a material loss and, otherwise, no material loss is experienced (i.e., Bernoulli). If the material loss occurs, the severity is normally distributed with a mean of $4 million and standard deviation of $2 million. What is the 95% expected shortfall?

A. $0.71 million

B. $3.29 million

C. $4.00 million

D. $7.29 million

***Answer: C***

ES = E(L | L >VaR). In this case, the 95% ES is the expected loss conditional on the loss occurring, which coincides with the mean of the normal distribution.

## 3 Weighted Historic Simulation Approaches

**Weighted Historic Simulation Approaches**
**(数据权重不同)**

**Age-weighted HS ★**
**(hybrid of EWMA & HS)**

$$w_{(i)} = \frac{\lambda^{i-1}(1-\lambda)}{1-\lambda^{n}}$$

计算

***advantages***

- Generalizes historical simulation (HS) (λ →1)
- more responsive to large losses & handling clusters of large losses
- reduce ghost effects
- option of letting our sample size grow over time

***Volatility-weighted HS*** → weight returns by relative volatility

$$r^{*}_{t,i} = \left(\frac{\sigma_{T,i}}{\sigma_{t,i}}\right) \times r_{t,i}$$

***advantages***

- Directly accounts for volatility changes
- Allows us to incorporate GARCH forecasts
- Can obtain estimates exceed maximum loss in actual datasets
- Empirical evidence to support superiority of estimates

***Correlation-weighted HS*** → major generalization of the volatility-weighted approach

***Filtered HS***

- bootstrapping + traditional HS with conditional volatility modeling (GARCH)
- Semi-Parametric Bootstrap

***do not make strong assumptions about the distribution*** ⬇ 优缺点 定性了解★

| Advantages | Disadvantages |
|---|---|
| • Intuitive<br>• Handle non-normal returns (skew, kurtosis)<br>• handle any position type including derivatives<br>• Popular among risk practitioners<br>• Relatively easy to implement (e.g., spreadsheet)<br>• No "curse of dimensionality"<br>• Uses readily available data (returns, volatility)<br>• Easy to report and communicate results<br>• Easy to generate confidence intervals<br>• Can be combined with parametric "add-ons" | • If history is a "quiet period," VAR (or ES) estimates will be too low<br>• Difficulty handling in-sample shifts (or regime changes)<br>• Can be dominated by extreme losses (not helpful if unlikely to occur)<br>• Most are subject to ghost effect (shadow effect)<br>• Generally make no allowance for plausible events that might occur but did not occur<br>• To an extent constrained by largest loss in historical dataset |

**3.1** Johanna Roberto has collected a data set of 1,000 daily observations on equity returns. She is concerned about the appropriateness of using parametric techniques as the data appears skewed. Ultimately, she decides to use historical simulation and bootstrapping to estimate the 5% VaR. which of the following steps is most likely to be part of the estimation procedure?

A. Filter the data to remove the obvious outliers.

B. Repeated sampling with replacement.

C. Identify the tail region from reordering the original data.

D. Apply a weighting procedure to reduce the impact of older data.

***Answer: B***

Bootstrapping from historical simulation involves repeated sampling with replacement. The 5% VaR is recorded from each sample draw. The average of the VaRs from all the draws is the VaR estimate. The bootstrapping procedure does not involve filtering the data or weighting observations. Note that the VaR from the original data set is not used in the analysis.



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**3.2** Jack has collected a large data set of daily market returns for three emerging markets and he want to compute the VaR. He is concerned about the non-normal skew in the data and is considering non-parametric estimation methods. Which of the following statements about Age-weighted historical simulation approach ismost accurate?

A. The age-weighted procedure incorporate estimates from GARCH model.

B. If the decay factor in the model is close to 1, there is persistence within the data set.

C. When using this approach, the weight assigned on day i is equal to:

$$w(i) = \lambda^{i-1}(1-\lambda)/1-\lambda^{i}$$

D. The number of observation should at least exceed 250.

***Answer: B***

If the intensity parameter (i.e., decay factor) is close to 1, there will be persistence (i.e., slow decay) in the estimate. The expression for the weight on day *i*has*i*in the exponent when it should be *n.* While a large sample size is generally preferred, some of the data may no longer be representative in a large sample.

**3.3** If volatility (0) is the current (today's) volatility estimate and volatility (t) is the volatility estimate on a previous day (t), which best describes volatility-weighted historical simulation?

A. First conduct typical historical simulation (HS) on return series. Then multiply VaR by volatility(0)/volatility(t)

B. First conduct typical historical simulation (HS) on return series. Then multiply VaR by volatility(t)/volatility(0)

C. Each historical return (t) is replaced by: return (t)*volatility (0)/volatility (t). Then conduct typical historical simulation (HS) on adjusted return series.

D. Each historical return (t) is replaced by: return (t)*volatility (t)/volatility (0). Then conduct typical historical simulation (HS) on adjusted return series.

***Answer: C***

Each historical return (t) is replaced by: return(t) × volatility(0)/volatility(t). Then conduct typical historical simulation (HS) on adjusted return series

For example, if on the historical day (t), the return(t) was -2.0% and volatility(t) was 10%, while today's volatility estimate is 20%, then the adjusted return is -2.0% × 20%/10% = - 4.0% . In this way, "Actual returns in any period t are therefore increased (or decreased), depending on whether the current forecast of volatility is greater (or less than) the estimated volatility for period t. We now calculate the HS P/L using [the adjusted returns] instead of the original data set, and then proceed to estimate HS VaRs or ESs in the traditional way (i.e., with equal weights, etc.).



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**3.4** All of the following approaches improve the traditional historical simulation approach for estimating VaR except the:

A. Volatility-weighted historical simulation.

B. Age-weighted historical simulation.

C. Market-weighted historical simulation.

D. Correlation- weighted historical simulation.

***Answer: C***

Market-weighted historical simulation is not discussed in this topical. Age-weighted historical simulation weights observations higher when they appear closer to the event date. Volatility-weighted historical simulation adjusts for changing volatility levels in the data. Correlation- weighted historical simulation incorporates anticipated changes in correlation between assets in the portfolio.

**3.5** Which of the following statements about volatility-weighting is true?

A. Historic returns are adjusted, and the VaR calculation is more complicated.

B. Historic returns are adjusted, and the VaR calculation procedure is the same.

C. Current period returns are adjusted, and VaR calculation is more complicated.

D. Current period returns are adjusted, and VaR calculation is the same.

***Answer: B***

The volatility-weighting method adjusts historic returns for current volatility. Specifically, return at time t is multiplied b (current volatility estimate/ volatility estimate at time t). However, the actual procedure for calculating VaR using a historical simulation method is unchanged; it is only the inputted data that changes.

**3.6** A risk manager is analyzing the output of an age-weighted historical VaR model. After a long period of high volatility, the market has been very stable recently. The risk manager is concerned that the output may underestimate the risk in the market. The model would generate a higher risk estimate by: (Important)

A. Using a lower VaR confidence level

B. Using volatility weighting in addition to age weighting.

C. Using bootstrapping to calculate VaR.

D. Using a smaller exponential rate of decay of the age weights.

***Answer: C***

## 4 Parametric Estimation Approaches



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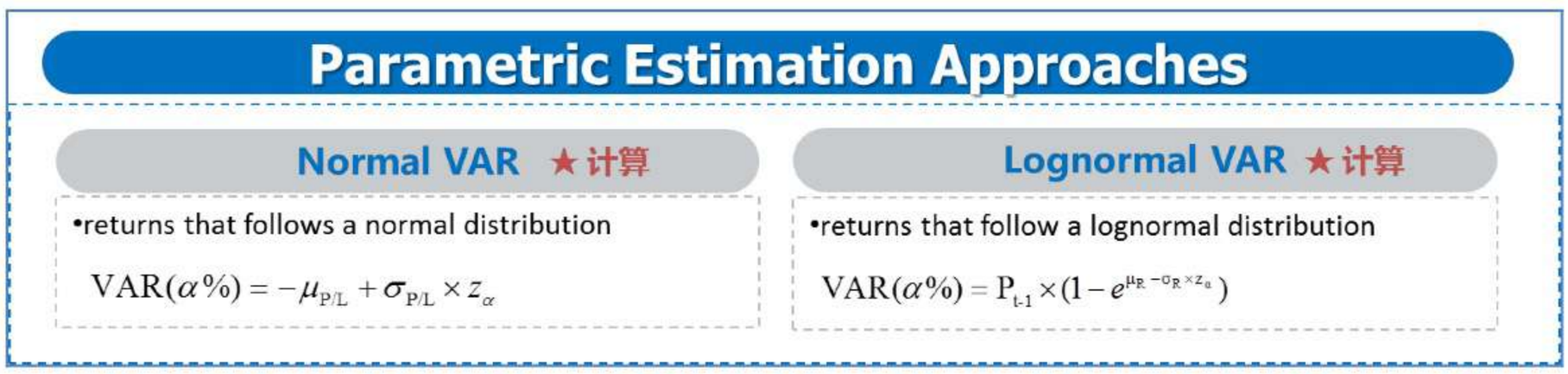


**4.1** The annual mean and volatility of a portfolio are 10% and 40%, respectively. The current value of the portfolio is GBP 1,000,000. How does the 1-year 95% VaR that is calculated using a normal distribution assumption (normal VaR) compare with the 1-year 95% VaR that is calculated using the lognormal distribution assumption (lognormal VaR)?

A. Lognormal VaR is greater than normal VaR by GBP 13,040

B. Lognormal VaR is greater than normal VaR by GBP 17,590

C. Lognormal VaR is less than normal VaR by GBP 13,040

D. Lognormal VaR is less than normal VaR by GBP 17,590

***Answer: C***

$$\text{Normal VaR} = 0.1 - (1.645 \times 0.4) = 0.558$$

$$\text{Lognormal VaR} = 1 - \exp\left[0.1 - (1.645 \times 0.4)\right] = 0.4276$$

Hence, lognormal VaR is smaller than Normal VaR by 13.04% per year. With a portfolio of GBP 1,000,000, this translates to GBP 13,040.

**4.2** The bank's trading book consists of the following two assets:

| Asset | Annual Return | Volatility of Annual Return | Value |
|---|---|---|---|
| A | 10% | 25% | 100 |
| B | 20% | 20% | 50 |

Correlation (A, B) = 0.2

How would the daily VaR at 99% level change if the bank sells 50 worth of asset A and buys 50 worth of asset B?

Assume there are 250 trading days in a year.

A. 0.2286

B. 0.4776

C. 0.7705

D. 0.7798



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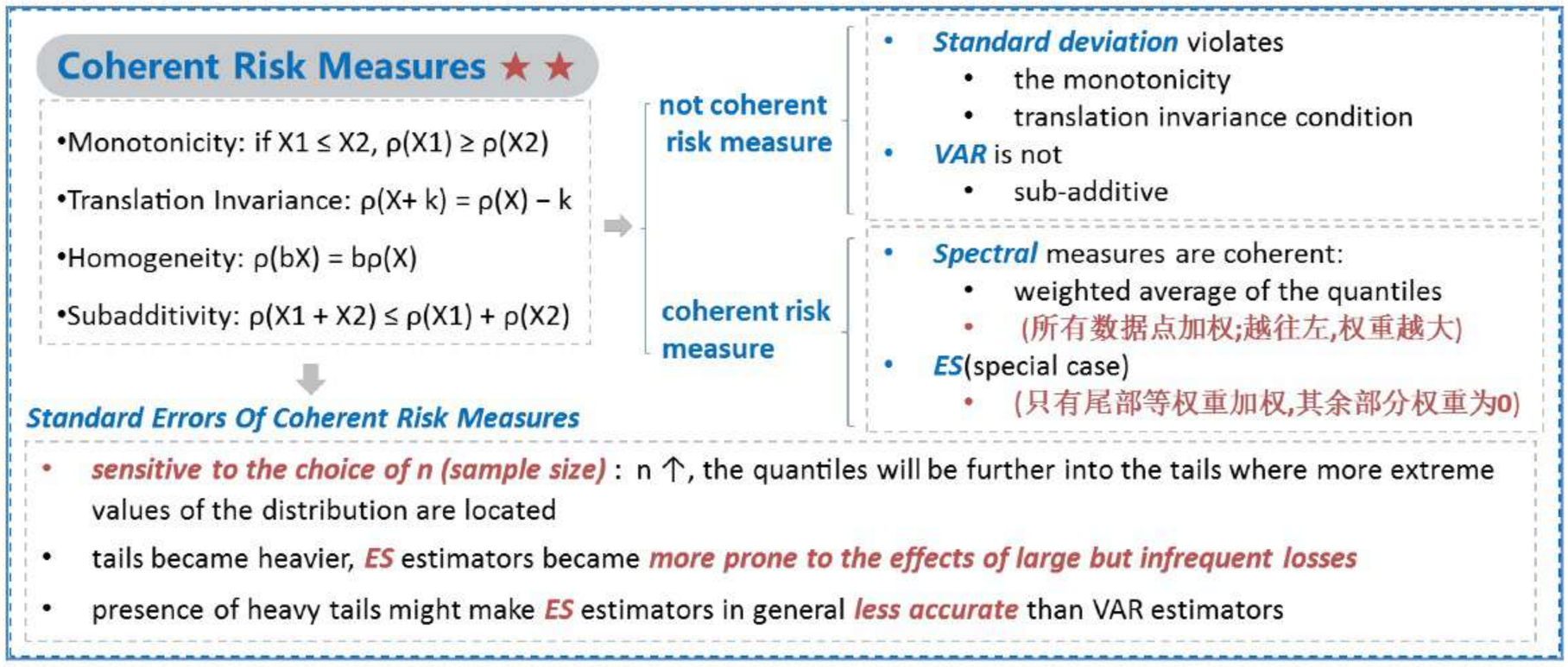
*Answer: B*

The trade will decrease the VaR by 0.4776

## 5 Coherent Risk Measures




**5.1** It is not always apparent how risk should be quantified for a given bank when there are many different possible risk measures to consider. Prior to defining specific measures, one should be aware of the general characteristics of ideal risk measures. Such measures should be intuitive, stable, easy to understand, coherent, and interpretable in economic terms. In addition, the risk decomposition process must be simple and meaningful for a given risk measure. Standard deviation, value at risk (VaR), expected shortfall (ES), and spectral and distorted risk measures are commonly used measures to calculate economic capital. However, it is not easy to select a risk measure to calculate economic capital, as each measure has its respective pros and cons. Which of the following statements pertaining to the pros and cons of these risk measures is not accurate?

A. Standard deviation does not have the property of monotonicity, and therefore, it is not coherent.

B. VaR does not have the property of subadditivity, and therefore; it is not coherent.

C. ES is not stable regardless of the loss distribution.

D. Spectral and distorted risk measures are neither intuitive nor commonly used in practice.

*Answer: C*

Expected shortfall's stability as a measure of risk depends on the loss distribution.

**5.2** Which of the following statements comparing VaR with expected shortfall is true?

A. Expected shortfall is sub-additive while VaR is not.



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B. Both VaR and expected shortfall measure the amount of capital an investor can expect to lose over a given time period and are, therefore, interchangeable as risk measures.

C. Both VaR and expected shortfall depend on the assumption of a normal distribution of returns.

D. VaR can vary according to the confidence level selected, but expected shortfall will not.

***Answer: A***

VaR measures the expected amount of capital one can expect to lose within a given confidence level over a given period of time. One of the problems with VaR is that it does not provide information about the expected size of the loss beyond the VaR.VaR is often complemented by the expected shortfall, which measures the expected loss conditional on the loss exceeding the VaR. Note that since expected shortfall is based on VaR, changing the confidence level may change both measures. A key difference between the two measures is that VaR is not sub-additive, meaning that the risk of two funds separately may be lower than the risk of a portfolio where the two funds are combined. Violation of the sub-additive assumption is a problem with VaR that does not exist with expected shortfall.

**5.3** Assume position (X) contains risk of R(X) and position (Y) contains risk of R(Y). Our analysis finds that the risk of the combined portfolio R(X+Y) is greater than the sum of the individual positions risks; i.e., we find R(X+Y) > R(X) + R(Y). This illustrates a violation of which coherence property?

A. Monotonicity

B. Subadditivity

C. Positive Homogeneity

D. Translational invariance

***Answer: B***

The diversification should make the portfolio less risky, or at the very least, equally risky. But the combination should not penalize diversification in terms of the risk metric.

**5.4** Which of the following is a true statement about expected shortfall (ES)?

A. ES is a coherent spectral measure which gives equal weight to the tail quantiles

B. ES is a coherent spectral measure which gives increasingly greater weight to higher tail quantiles

C. ES is a coherent spectral measure but gives decreasingly less weight to higher tail quantiles

D. ES is coherent, VaR is not coherent, and neither are spectral measures

***Answer: A***



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ES is a coherent spectral measure which gives equal weight to the tail quantiles. The general class is spectral measures, which contain a weighting function. Both ES and VaR are special cases of a spectral measure (the spectral function generalized both ES &VaR). Spectral measures are coherent under conditions that are met by ES but not by VaR; "Spectral" is associated with, but does not necessarily imply, coherence.

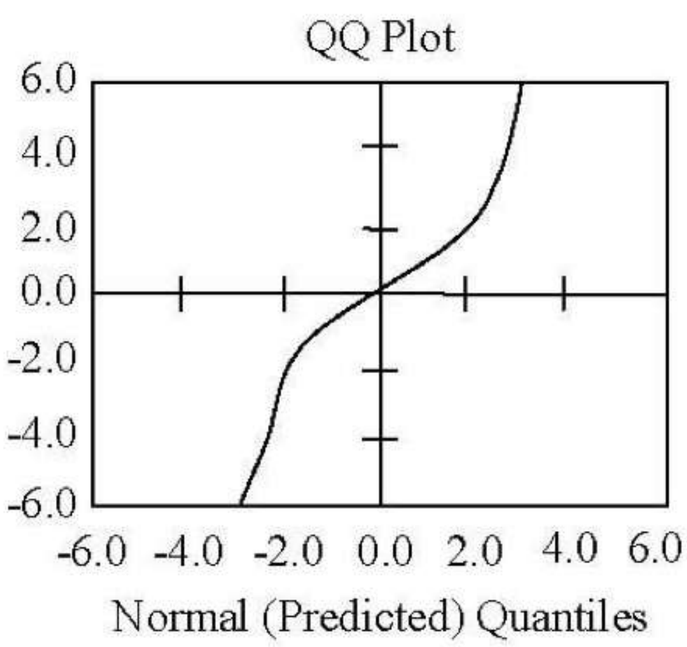
## 6 Quantile-Quantile Plots

**QQ plot ★**

- predicted quantile against the empirical quantile
- *linear* QQ plot indicates a *good fit* to the distribution
- departures from linearity can tell whether the tails of empirical distribution are fatter, or thinner

**6.1** Consider the following QQ plot:

Empirical Quantiles






Which is the most likely true statement about the QQ plot?

A. The empirical distribution is actually parametric.

B. The empirical distribution has positive skew.

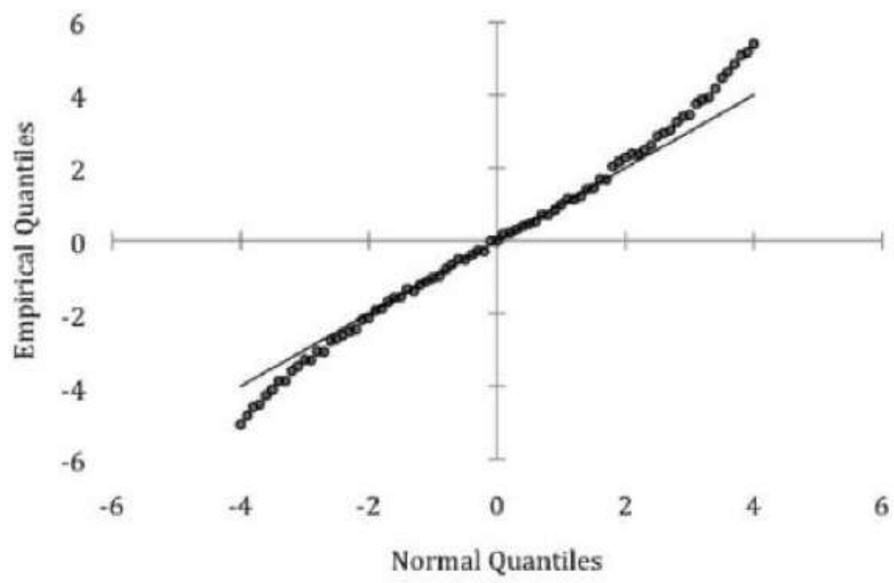
C. The empirical distribution has leptokurtosis (kurtosis>0)

D. If we perform a linear transformation of location and scale, the distribution is approximately normal.

***Answer: C***

Heavy tails: the steeper slope - i.e., greater than 1.0 - at the tails indicates the tails are heavier than the reference distribution

**6.2** An analyst is examining a sample of return data. As a first step, the analyst construct a QQ plot of the data as shownbelow:




Based on an examination of the QQ plot, which of the following statements is correct? (Practice Exam)

A. The returns are normally distributed.

B. The return distribution has thin tails relative to the normal distribution.

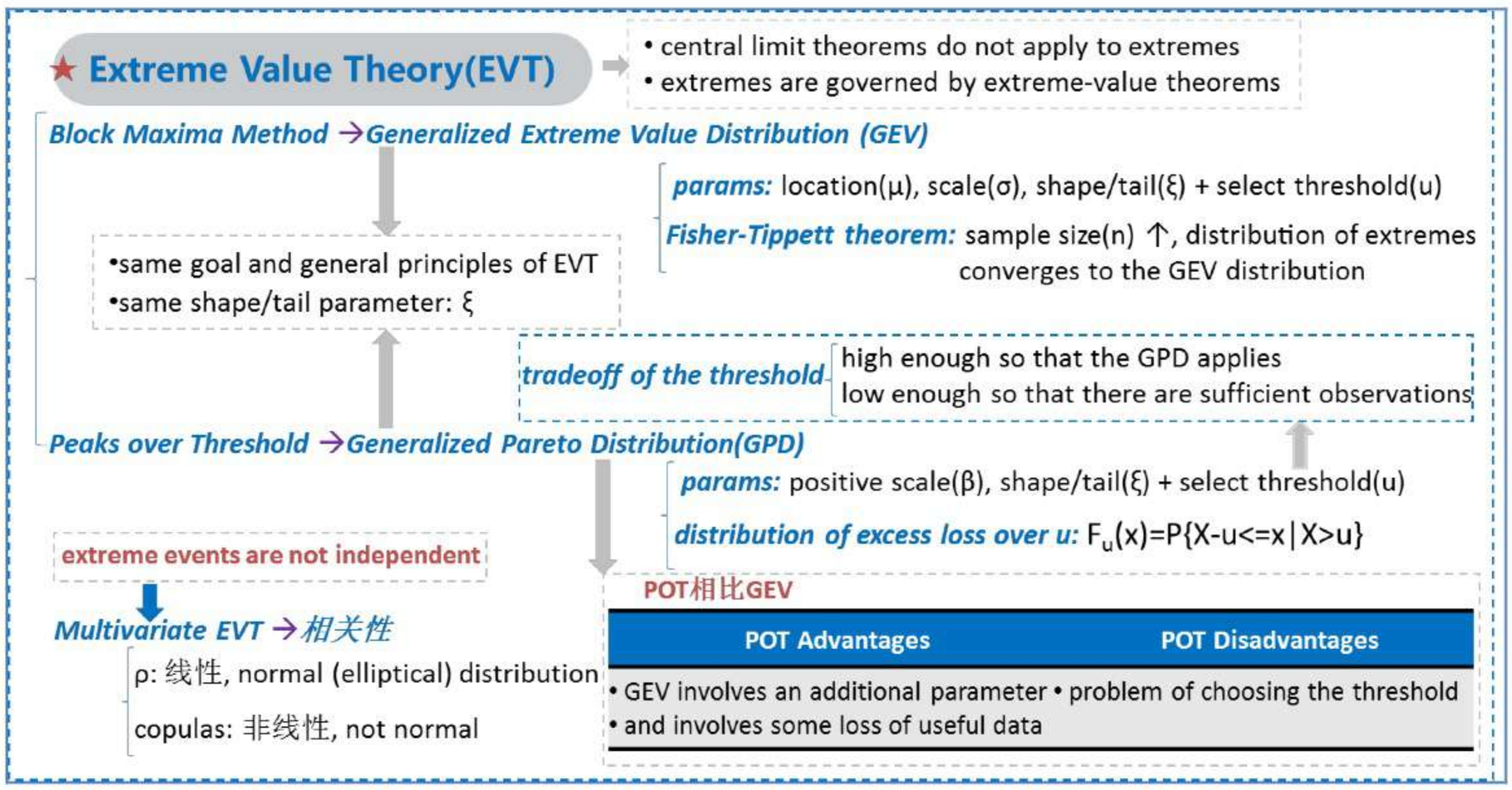
C. The return distribution is negatively skewed relative to the normal distribution.

D. The return distribution has fat tails relative to the normal distribution.

***Correct answer: d***

Explanation: This Q-Q plot has steeper slopes at the tails of the plot, which indicate fat tails in thedistribution. A normal distribution would result in a linear QQ plot. A distribution with thin tails would producea QQ plot with less steep slopes at the tails of the plot than a linear relationship, while this one is steeper atthe tails. It is not a negatively skewed distribution, as the Q-Q plot is symmetric.

## 7 Extreme Value



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**7.1** Which of the following statements regarding extreme value theory (EVT) is incorrect?

A. In contrast to conventional approaches for estimating VaR, EVT only considers the tail behavior of the distribution.

B. Conventional approaches for estimating VaR that assume that the distribution of returns follows a unique distribution for the entire range of values may fail to properly account for the fat tails of the distribution of returns.

C. EVT attempts to find the optimal point beyond which all values belong to the tail and then models the distribution of the tail separately.

D. By smoothing the tail of the distribution, EVT effectively ignores extreme events and losses that can generally be labeled outliers.

***Answer: D***

EVT only uses information in the tail, so statement a. is correct. Conventional approaches such as delta-normal VaR assume a fixed p.d.f. for the entire distribution, which may understate the extent of fat tails. So, statement b. is correct. The first step in EVT is to choose a cutoff point for the tail, then to estimate the parameters of the tail distribution, so statement c. is correct. Finally, EVT does not ignore extreme events (as long as they are in the sample).

**7.2** The peaks-over-threshold approach generally requires:

A. More estimates parameters than the GEV approach and shares one parameter with the GEV.

B. Fewer estimates parameters than the GEV approach and shares one parameter with the GEV.

C. More estimates parameters than the GEV approach and does not shares any parameter with the GEV approach.

D. Fewer estimates parameters than the GEV approach and does not shares any parameter with the GEV approach.

***Answer: B***

The POT approach generally has fewer parameters, but both POT and GEV approaches share the tail parameter$\xi$

**7.3** According to extreme value theory (EVT), when examining distributions of losses exceeding a threshold value, which of the following is correct? (Practice Exam)

A. To apply EVT, the underlying loss distribution must be either normal or lognormal.

B. The threshold value is typically chosen near the estimated mean of the underlying loss distribution.

C. The number of exceedances decreases as the threshold value decreases, which causes the reliability of the parameter estimates to increase.



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D. As the threshold value is increased, the distribution of exceedances converges to a generalized Pareto distribution.

***Answer: D***

A key foundation of EVT is than as the threshold value is increased, the distribution of loss exceedances converges to a generalized Pareto distribution. Assuming the threshold is high enough, excess losses can be modeled using the Generalized Pareto distribution.

To apply EVT, the underlying loss distribution can be any of the commonly used distributions: normal, lognormal, t, etc., and will usually be unknown.

Choosing the threshold value near the estimated mean of the underlying loss distribution is arbitrary and this method is not typically employed.

As the threshold value is decreased, the number of exceedances increases.

**7.4** In setting the threshold in the POT approach, which of the following statements is the most accurate? Setting the threshold relatively high makes the model:

A. More applicable but decreases the number of observations in the modeling procedure.

B. Less applicable and decreases the number of observations in the modeling procedure.

C. More applicable but increases the number of observations in the modeling procedure.

D. Less applicable but increases the number of observations in the modeling procedure.

***Answer: A***

There is a trade-off in setting the threshold. It must be high enough for the appropriate theorems to hold, but if set too high, there will not be enough observations to estimate the parameters.

**7.5** Let X be a random variable representing the daily loss of your portfolio. The "peaks over threshold" (POT) approach considers a threshold value, u, of X and the distribution of excess losses over this threshold. Which of the following statements about this application of extreme value theory is correct? (Practice Exam)

A. To apply the POT approach, the distribution of X must be elliptical and known.

B. If X is normally distributed, the distribution of excess losses requires the estimation of only one parameter, β, which is a positive scale parameter.

C. To apply the POT approach, one must choose a threshold, u, which is high enough that the number of observations in excess of u is zero.

D. As the threshold, u, increases, the distribution of excess losses over u converges to a generalized Pareto distribution.

***Answer: D***

The distribution of excess losses over u converges to a generalized Pareto distribution as the threshold value u increases.



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The distribution of X itself can be any of the commonly used distribution: normal, lognormal, t, etc., and will usually be known. The distribution of excess losses requires the estimation of two parameters, a positive scale parameter β and a shape or tail index parameter ξ. One must choose a threshold u that is high enough so that the theory applies but also low enough so that there are observations in excess of u.

# 2 Backtesting VAR

## Backtesting VAR

### Backtesting VAR

process of comparing losses predicted by the VAR model to those actually experienced over the testing period

***Difficulties in backtesting a VAR model***

- statistical decision(not 100% confidence)
- assumes a static portfolio →
  - contamination minimized in short horizons
  - track both actual and hypothetical return
  - cleaned-return (consider Transaction fee)

***Process Of Model Verification***

★ 计算

- *failure rate(Bernoulli trials)* →binomial probability distribution(x: number of exceptions)

$$f(x)=\binom{T}{x}p^{x}(1-p)^{T-x}$$

- *假设检验*: central limit theorem(binomial distribution →normal distribution)

$$z=\frac{x-pT}{\sqrt{p(1-p)T}}\sim N(0,1)$$

  - $H_0$: accurate model
  - $H_a$: inaccurate model

## Other Issues

***Type I And Type II Errors*** →

- ***Probability of Type I error*** (mistakenly reject null) = α = level of significance
- ***Probability of Type II error*** (mistakenly accept null) =β(difficult to calculate)

**Null: Model is correctly calibrated**

| Decision | Null is correct | Null is incorrect |
|---|---|---|
| Accept * | Good decision! | Type 2 Error |
| Reject | Type 1 Error | Good decision! |

*** Technically, "accept" = "Do not reject"**
**(as a jury finds defendant "not guilty" instead of "innocent")**

- ***Unconditional Coverage Model***: ignores time variation(reflects "independence" in the i.i.d. assumption)
- ***Conditional coverage models***: analyze exceptions conditional on current condition

**Backtesting Exceptions**

Using Failure Rates in Model Verification
- $H_0$: accurate model
- $H_a$: inaccurate model

★ 重要数字

- Test statistic(LR)
- If LR>**3.84**, we would reject the hypothesis(the model is correct)



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## The Basel Rules For Backtesting

***Basel internal approach(market risk) :*** 10-day 99.0% VAR model ★★

Over 250 observations in one year, the excpected number of exceptions is 0.01 * 250 = 2.5

***Four categories of causes for exceptions:***

- The basic integrity of the model is lacking. The ***penalty*** should ***apply***.
- Model accuracy needs improvement. The ***penalty*** should ***apply***.
- Intraday trading activity. The penalty should be ***considered***.
- Bad luck. The market significantly varied.

**The Basel Committee decided** ★★

**Three Zones**

| Zone | # of Exceptions | Increase in Scaling Factor (k) |
|---|---|---|
| Green | 0-4 | 0 |
| Yellow | 5 | 0.40 |
| | 6 | 0.50 |
| | 7 | 0.65 |
| | 8 | 0.75 |
| | 9 | 0.85 |
| Red | 10 or more | 1.00 |

## 1 BacktestingVaR

**1.1** Which of the following statements regarding verification of a VaR model by examining its failure rates is false?

I.The frequency of exceptions should correspond to the confidence level used for the model.

II.According to Kupiec (1995), we should reject the hypothesis that the model is correct if the LR > 3.84.

III.BacktestingVaR models with lower confidence levels is difficult because the number of exceptions is not high enough to provide meaningful information.

IV.The range for the number of exceptions must strike a balance between the chances of rejecting an accurate model (a type 1 error) and the chance of accepting an inaccurate model (a type2 error)

A. I and IV

B. II only

C. III only

D. II and IV

***Answer: C***

BacktestingVaR models with higher confidence levels is difficult because the number of exceptions is not high enough to provide meaningful information.

**1.2** Basel II requires a backtest of a bank's internal value at risk (VaR) model (IMA). Assume the

bank's ten-day 99% VaR is $1 million (minimum of 99% is hard-wired per Basel). The null hypothesis is: the VaR model is accurate. Out of 1,000 observations, 25 exceptions are observed (we saw the actual loss exceed the VaR 25 out of 1000 observations).　(Binomial CDF)

A. We will probably call the VaR model good (accurate) but we risk a Type I error.

B. We will probably call the VaR model good (accurate) but we risk a Type II error.

C. We will probably call the model bad (inaccurate) but we risk a Type I error.

D. We will probably call the model bad (inaccurate) but we risk a Type II error.

***Answer: C***

The probability of 25 or more exceptions will only be observed 1 – 99.996%. So, we reject the model.

Null = good model. To decide the model is bad model is to reject null and this implies a risk of type I error.

**1.3** A bank conducted a backtest of its 95% daily value at risk (VaR) and observed 19 exceptions - i.e., the number of days where the daily P&L loss exceeded the VaR - over the last year which included 250 trading days (T = 250). If we use the normal distribution to approximate the binomial for purposes of model verification, what is our accept/reject opinion of the model under a 90% two-tailed test?

A. Accept with a test statistic of 1.25

B. Accept with a test statistic of 1.89

C. Reject with a test statistic of 1.25

D. Reject with a test statistic of 1.89

***Answer: D***

Null hypothesis is H0: Model is good with E[exceptions] = (1 - 95%) × 250 = 12.5 exceptions

The standard error (standard deviation) of the binomial variable = SQRT[p(1-p)T] = SQRT(5% × 95% × 250) = 3.446

The test statistic is [19 - 12.5] / 3.446 = 1.89

In words, we observed 6.5 more exceptions (19 - 12.5) than expected if the model is good, which is 1.89 standard deviations away from the expected number of exceptions. Since we know that a 95% one-tailed normal confidence interval implies a 1.645 cutoff, we know that 1.645 is also the cutoff for a 90% two-tailed since the normal is symmetrical, this falls outside the acceptance region. We reject the null, assuming that luck does not explain this, and find the model faulty.

**1.4** You are backtesting a bank's VaR model. Currently, the bank calculates a 1-day VaR at the 99% confidence level, and you are recommending that is switch to a 95% confidence level. Which of the following statements concerning this switch is correct?(Practice Exam)



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A. The 95% VaR model is less likely to be rejected using backtesting than the 99% VaR model.

B. When validating with backtesting at the 90% confidence level, there is a smaller probability of incorrectly rejecting a 95% VaR model when it is valid than a 99% VaR model.

C. The decision to accept or reject a VaR model based on backtesting results is more reliable with a 95% confidence level VaR model than with a 99% confidence level model.

D. When backtesting using a 90% confidence level, there is a smaller probability of committing a type I error when backtesting a 95% VaR model than with a 99% VaR model.

***Answer: C***

The concept tested here is the understanding of the difference between the VaR parameter for confidence (here, namely 95% vs 99%) and the validation procedure confidence level, and how they interact with one another. Using a VaR confidence level creates a narrower rejection region by allowing a greater number of exceptions to be generated. This in turn increases the power of the backtesting process and makes for a more reliable test.

**1.5** Based on Basel II rules for backtesting, a penalty is given to banks that have more than four exceptions to their 1-day 99%VaR over the course of 250 trading days. The supervisor gives these penalties based on four criteria. Which of the following causes of exceptions is most likely to lead to a penalty? (Practice Exam)

A. The bank increases its intraday trading activity.

B. A large move in interest rates was combined with a small move in correlations.

C. The bank's model calculates interest rate risk based on the median duration of the bonds in the portfolio.

D. A sudden market crisis in an emerging market leads to losses in the equity positions in that country.

***Answer: C***

In the case of a bank that changed positions more frequently during the day, a penalty should be considered, but it is not necessarily given. In the case of bad luck, no penalty is given, as would be the case for a bank affected by unpredictable movements in rates or markets. However, when risk models are not precise enough, a penalty is typically given since model accuracy could have easily been improved.

**1.6** A risk manager is analyzing a 1-day 99% VaR model. Assuming 225 days in a year, what is the maximum number of daily losses exceeding the 1-day 99% VaR that is acceptable in a 1-year backtest to conclude, at a 95% confidence level, that the model is calibrated correctly? (Practice Exam)



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A. 3

B. 5

C. 8

D. 10

***Answer: B***

The risk manager will reject the hypothesis that the model is correctly calibrated if the number x of losses exceeding the VaR is such that:

$$\frac{x-pT}{\sqrt{p(1-p)T}} > z = 1.96$$

where p represents the failure rate and is equal to 1 – 99%, or 1%; and T is the number of observations = 225. And z = 1.96 is the two-tail confidence level quantile. If:

$$\frac{x-0.01\times 225}{\sqrt{0.01\times(1-0.01)\times 225}} = 1.96$$

Then, x = 5.18. So the maximum number of exceedances would be 5 to conclude that the model is calibrated correctly.

**1.7** A portfolio risk analyst, who specializes in large capitalization US stocks, is backtesting the firm's VaR model using two procedures:



Procedure A: Using the "actual return" approach ,the analyst measures the returns on a portfolio based upon the change in market values of the assets hold in the portfolio from the close of each business day to the close of the next business day.

Procedure B: Using the "hypothetical return" approach ,the analyst measures the returns on a portfolio based upon the change in market values of the assets held in the portfolio from the close of each business day to the close of the next business day, keeping all positions fixed.

The two procedures result in significantly different numbers of exceptions. The most likely cause of the different number of exceptions is: (Important)

A. Poor calibration of the VaR model.

B. Intraday trading in the portfolios,

C. Incorrect return distribution assumptions used in Procedure A;

D. The reduction of hypothetical returns by commission fees.

***Answer: B***

**1.8** A risk analyst is asked to verily a VaR model by checking the rate of exceedances of the

model. In the past year, there were eight exceedances of the 99% VaR. Is this evidence sufficient to reject the hypothesis, using a 99% test confidence level, that this particular VaR model is unbiased? (Important)

A. No. because the computed z = 2.20.

B. No. because the computed z = 2.29.

C. Yes, because the computed z = 2.87.

D. Yes, because the computed z = 3.47.

***Answer: D***

# 3 VAR Mapping

## VAR Mapping

***Mapping replaces current portfolio position values with exposures to risk factors.***

***Mapping Principles***

- positions can be simplified to smaller number of positions on set of risk factors
- when instrument characteristics change over time.
- only solution to data (shortage) problem


## Mapping Portfolios Of Fixed Income Securities

★ **Mapping Approaches to fixed-income portfolios** ➡ 掌握基础班讲义例题★

| Principal mapping | Duration mapping | Cash flow mapping |
|---|---|---|
| •One risk factor (portfolio principal)<br>•Bond risk = average portfolio maturity | •One risk factor<br>•(portfolio duration)<br>•Bond risk = zero-coupon bond with maturity equal to the bond duration | •Several risk factors<br>•Bond risk = decomposed into risk of each of the bond cash flows |

***linear Derivatives → Delta-normal method***

$$VAR(dP) = |-D^{*}P| \times VAR(dy)$$
$$VAR(dc) = |\Delta| \times VAR(dS)$$

***nonlinear Derivatives →Delta-Gamma method***

$$VAR(dP) = |-D^{*}P| \times VAR(dy) - (1/2)(C \times P) \times VAR(dy)^2$$
$$VAR(dc) = |\Delta| \times VAR(dS) - (1/2)\,\Gamma \times VAR(dS)^2$$

★记忆方法: 凸性的好处→降低风险

***Stress Testing***

- This stress test generates a distribution of present value factors that can be used to re-price the portfolio

***VAR Relative To A Benchmark Portfolio***

- Benchmarking a portfolio: measuring VAR relative to a benchmark portfolio
- $\text{Tracking Error VAR} = \alpha\sqrt{(x - x_o)' \sum (x - x_o)}$



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# 1 Risk Factor

**1.1** Which of the following can be considered a general risk factor?

I.Exchange rate

II.Mortgage-backed securities

III.Zero-coupon bond

IV.Interest rate

A. I only

B. II and III

C. III only

D. I and IV

***Answer: D***

**1.2** Computing VaR on a portfolio containing a very large number of positions can be simplified by mapping these positions to a smaller number of elementary risk factors. Which of the following mappings would be adequate? (Practice Exam)

A. USD/EUR forward contracts are mapped on the USD/JPY spot exchange rate.

B. Each position in a corporate bond portfolio is mapped on the bond with the closest maturity among a set of government bonds.

C. Government bonds paying regular coupons are mapped on zero-coupon government bonds.

D. A position in the stock market index is mapped on a position in a stock within that index.

***Answer: C***

Mapping government bonds paying regular coupons onto zero coupon government bonds is an adequate process, because both categories of bonds are government issued and therefore have a very similar sensitivity to risk factors. However, this is not a perfect mapping since the sensitivity of both classes of bonds to specific risk factors (i.e., changes in interest rates) may differ.

# 2 Mapping to Fixed Income Portfolios

**2.1** An analyst is using the delta-normal method to determine the VaR of a fixed income portfolio. The portfolio contains a long position in 1-year bonds with a $1 million face value and a 6% coupon that is paid semi-annually. The interest rates on six-month and twelve-month maturity zero-coupon bonds are, respectively, 2% and 2.5%. Mapping the long position to



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standard positions in the six-month and twelve-month zeros, respectively, provides which of the following mapped positions?

A. $30,000 and 1,030,000

B. $29,500 and 975,610

C. $29,703 and 1,004,878

D. $30,300 and 1,035,000

***Answer: C***

The long position is mapped into a combination of market values of the zero-coupon bonds that provide the same cash flows:

$$X_{six} = \frac{30,000}{1+(0.02/2)} = 29,703$$

$$X_{twelve} = \frac{1,030.000}{1+(0.025)} = 1,004,878$$

**2.2** Delta-normal VaR will provide accurate estimates for option contracts when:

A. Deltas are stable

B. Options are at the money

C. The correlation matrix is available

D. The delta-normal method can never be used for option contracts

***Answer: A***

Delta-normal VaR methods will provide accurate estimates of VaR for options only over those ranges in which the deltas of the contracts are stable. Deltas are normally unstable near the money and close to expiration.

**2.3** Under these assumptions - in particular: a flat yield curve and constant yield volatility of 1.0% - why can we expect cash flow mapping to produce a lower diversified VaR than either duration and principal mapping?

A. The risk measures are non-linear.

B. Due to imperfect correlations between pairwise risk factors.

C. Fewer total cash flows will be mapped.

D. We cannot expect a lower diversified VaR.

***Answer: B***

The diversified VaR is lower due to two factors. First, risk measures are not perfectly linear with maturity. Second, correlations are below unity, which reduces risk even further.



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**2.4** Which of these statements regarding risk factor mapping approaches is/are correct?

I.Under the cash flow mapping approach, only the risk associated with the average maturity of a fixed-income portfolio is mapped.

II.Cash flow mapping is the least precise method of risk mapping for a fixed-income portfolio.

III.Under the duration mapping approach, the risk of a bond is mapped to a zero-coupon bond of the same duration.

IV.Using more risk factors generally leads to better risk measurement but also requires more time to be devoted to the modeling process and risk computation.

A. I and II

B. I, III, and IV

C. III and IV

D. IV only

***Answer: C***

Under the cash flow mapping approach, each payment (and not only the last one) is associated with a different risk factor, so statement I. is incorrect. Statement II.is incorrect because the CF mapping approach is more correct than duration or maturity mapping.

**2.5** In fixed income portfolio mapping, when the risk factors have been selected, which of the following mapping approaches requires that one risk factor be chosen that corresponds to average portfolio maturity? (Practice Exam)

A. Principal mapping

B. Duration mapping

C. Convexity mapping

D. Cash mapping

***Correct answer: a***

Explanation: With principal mapping, one risk factor is chosen that corresponds to the average portfolio maturity. With duration mapping, one risk factor is chosen that corresponds to the portfolio duration. With cashflow mapping, the portfolio cashflows are grouped into maturity buckets. Convexity mapping is not a method of VaR mapping for fixedincome portfolios.

## 3 Mapping to Option Position

**3.1** A portfolio manager owns a portfolio of options on a non-dividend paying stock RTX. The portfolio is made up of 10,000 deep in-the-money call options on RTX and 50,000 deep out-of-the money call options on RTX. The portfolio also contains 20,000 forward contracts on



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RTX. RTX is trading at USD 100. If the volatility of RTX is 30% per-year, which of the following amounts would be closest to the 1-day VaR of the portfolio at the 95 percent confidence level, assuming 252 trading days in a year?

A. USD 932

B. USD 93,263

C. USD 111,122

D. USD 131,892

*Answer: B*

We need to map the portfolio to a position in the underlying stock RTX. A deep in-the-money call has a delta of approximately 1, a deep out-of-the-money call has delta of approximately 0 and forwards have a delta of 1. The net portfolio has a delta of about 30,000 and is approximately gamma neutral. The 1-day VaR estimate at 95 percent confidence level is computed as follows:

$$\alpha \times S \times \Delta \times \sigma \times \text{sqrt}(1/T) = 1.645 \times 100 \times 30{,}000 \times 0.30 \times \text{sqrt}(1/252) = 93{,}263$$

**3.2** A portfolio consists of options on Microsoft and AT&T. The options on Microsoft have a delta of 1000, and the options on AT&T have a delta of 20000. The Microsoft share price is $120, and the AT&T share price is $30. Assuming that the daily volatility of Microsoft is 2% and the daily volatility of AT&T is 1% and the correlation between the daily changes is 0.3, the 5-day 95% VaR is

A. 26193

B. 25193

C. 27193

D. 24193

*Answer: A*

$VaR_{Mic} = 1.65 \times 2\% \times 120 \times 1000 = 3960$

$VaR_{AT\&T} = 1.65 \times 1\% \times 30 \times 20000 = 9900$

$$VaR_{P(5-\text{day},\ 95\%)} = \sqrt{3960^2 + 9900^2 + 2 \times 0.3 \times 3960 \cdot 9900} \times \sqrt{5} = 26193$$

**3.3** A trader has an option position in crude oil with a delta of 100000 barrels and gamma of -50000 barrels per dollar move in price. Using the delta-gamma methodology, compute the VaR on this position, assuming the extreme move on crude oil is $2.00 per barrel.

A. $100,000

B. $200,000

C. $300,000



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D. $400,000

***Answer: C***

$$\text{VaR}(df) = \Delta \times \text{VaR}(dS) + (1/2)\Gamma \times \text{VaR}(dS)^2$$

$$\text{VaR}(df) = 100{,}000 \times (-2.00) + (1/2)(-50{,}000) \times (-2.00)^2 = -\$300{,}000$$

# 4 Correlation Risk Modeling and Management

## 1　Some Correlation Basics

### Some Correlation Basics

通常假设ρ不变 —correlation change→ Financial Correlation Risk

the risk of financial loss due to adverse movements in correlation between two or more (financial) variables

*Eg. Wrong-way risk:* adverse correlation between a bond issuer and the bond insurer

危机时的ρ变化规律

During a severe systemic crisis, an increase in correlation is typical

High diversification is related to low correlation

影响ρ因素 nonfinancial variables

- Sovereign debt and currency value
- Geopolitical tensions
- Correlated markets and economies

Trading And Correlation

hedge

*Multi-Asset Options*

correlation↓, option price↑, except Option on the worse of two

- Option on the better of two. Payoff = max(S1, S2).
- Option on the worse of two. Payoff = min(S1, S2).
- Call on the maximum of two. Payoff = max[0, max(S1,S2) – K].
- Exchange option (as a convertible bond). Payoff = max(0, S2−S1).
- Spread call option. Payoff = max[0,(S2−S1) −K].
- Option on the better of two or cash. Payoff = max(S1, S2, cash).
- Dual-strike call option. Payoff = max(0,S1−K1, S2−K2).

*Quanto option*(protects an investor against currency risk) → *know two things*

- how deep in the money
- exchange rate



### Tools to Hedge Correlation Risk

**直接hedge ρ**

*Correlation Swap ★ : fixed correlation ←→ realized/stochastic correlation*

payer→long correlation→correlation ↑ gain

receiver→short correlation→correlation ↓ gain

$$\rho_{\text{realized}} = \frac{\sum_{i>j} \rho i, j}{\frac{n \times (n-1)}{2}}$$

**间接hedge σ**　→*positive relationship between correlation and volatility*

*Buy Call On Index And Sell Call On Individual*

- Long Index Call
- Short Component Call

*Variance Swap*

- pay fixed in a variance swap on an index and
- to receive fixed in variance swaps on individual components of the index.

If correlation increases, so will the variance. ★



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## Correlation And Financial Crisis Of 2007 To 2009

了解

**Causes Of The Crisis** ➡
- Increased speculation fueled by loose credit
- Complex credit products
- Model risk
- Moral hazards
- Increased risk appetite

**First correlation-related crisis** ➡
- May 2005
- the correlations of the assets in the CDO decreased, the hedge funds lost on both positions

## Correlation Risk and Risk Management

***Market risk*** (comprised of equity risk, interest rate risk, currency risk, and commodity risk)

***Market risk implicitly incorporates correlation risk***

结论

构成

***Credit risk*** ➡
- Migration risk
- Default risk

⬅ the higher the correlation, the higher the probability of total loss

事实

period 1981 to 2001 ➡
- Default correlations between industries are mostly positive with the exception of the energy sector
- The default correlation within sectors is higher than between sectors

sector-diversified loan portfolio to reduce default correlation risk

term structure of defaults ➡
- most investment grade bonds, the term structure of default probabilities increases in time
- bonds in distress, the default term structure is typically inverse

***Systemic risk*** ➡ Systemic risk and correlation risk are highly dependent

***Concentration risk*** ➡ High sector diversification reduces default risk

## How Do Correlations Behave in the Real World

结论

***Equity Correlation Behaviors***
- Correlation levels are lowest in strong economic growth times.
- In recessions, correlation levels typically increase.
- Correlation volatility is lowest in an economic expansion and highest in worse economic states.
- Positive relationship between correlation level and correlation volatility

***Mean reversion*** ➡
- Fixed coupon bonds exhibit strong mean reversion
- Interest rates are assumed to be mean reverting

经济周期

***Autocorrelation*** ➡ Time lag 2 autocorrelation is highest★

the autocorrelation of 22.49% and the strong mean reversion of 77.51% sum to 1.0

**1.1** A risk manager uses the past 480 months of correlation data from the Dow Jones Industrial Average (Dow) to estimate the long-run mean correlation of common stocks and the mean reversion rate. Based on historical data, the long-run mean correlation of Dow stocks was 32%, and he regression output estimates the following regression relationship: Y = 0.215 - 0.75 X.



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Suppose that in April 2014, the average monthly correlation for all Dow stocks was 36%. What is the expected correlation for May 2014 assuming the mean reversion rate estimated in the regression analysis?

A. 32%

B. 33%

C. 35%

D. 37%

***Answer: B***

There is a -4% difference from the long-run mean correlation and April 2014 correlation (32% - 36% = -4%). The inverse of the β coefficient in the regression relationship implies a mean reversion rate of 75%. Thus, the expected correlation for May 2014 is 33.0%:

$S_t = a(\mu - S_{t-1}) + S_{t-1}$

$S_t = 0.75(32\% - 36\%) + 0.36 = 0.33$

**1.2** A risk manager uses the past 480 months of correlation data from the Dow Jones Industrial Average (Dow) to estimate the long-run mean correlation of common stocks and the mean reversion rate. Based on historical data, the long-run mean correlation of Dow stocks was 34%, and he regression output estimates the following regression relationship: Y = 0.215 - 0.77X. Suppose that in April 2014, the average monthly correlation for all Dow stocks was 33%. What is the estimated one-period autocorrelation for this time period based on the mean reversion rate estimated in the regression analysis?



A. 23%

B. 26%

C. 30%

D. 33%

***Answer: A***

The autocorrelation for a one-period lag is 23% for the same sample. The sum of the mean reversion rate (77% given the beta coefficient of -0.77) and the one-period autocorrelation rate will always equal 100%.

**1.3** The long-term mean of the correlation data is 35%. In January 2014, the averaged correlation of the 30 × 30 Dow correlation matrices was 27%.From the regression function from 1972 to 2012, the average mean reversion was 77.5%. Using the simple s(t) - s(t-1) = alpha × [μ - s(t - 1)] model, what is the expected correlation for February 2014?

A. 27.75%

B. 28.80%



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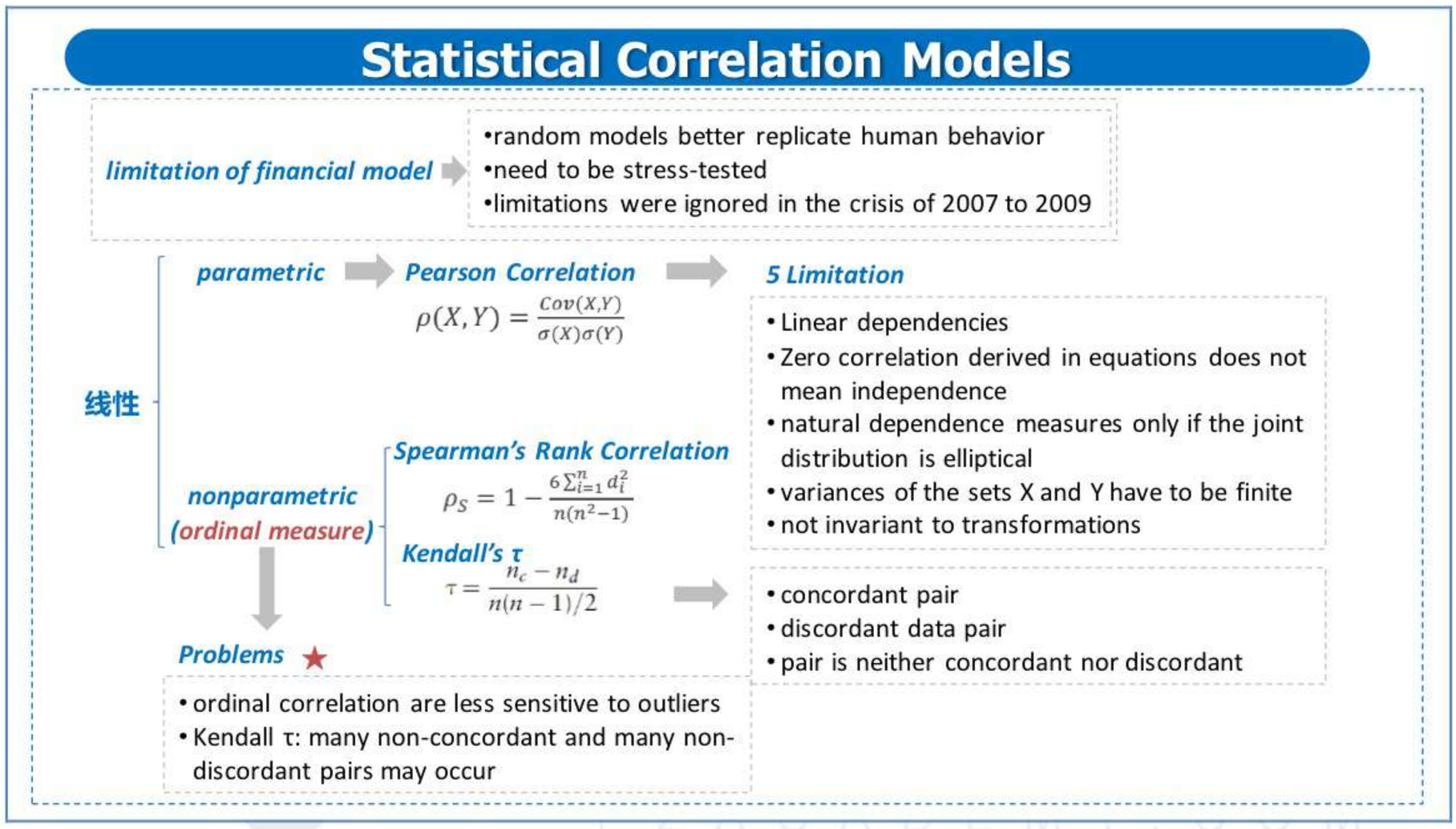
C. 33.20%

D. 37.50%

***Answer: C***

33.20% = 27.0% + 77.5% × (35.0% - 27.0%)

## 2 Statistical Correlation Models




**2.1** A risk manager gathers five years of historical returns to calculate the Spearman rank correlation coefficient for stocks X and Y from 2010 to 2014 are as follows:

| Year | X | Y |
|---|---|---|
| 2010 | 5.0% | -10.0% |
| 2011 | 50.0% | -5.0% |
| 2012 | -10.0% | 20.0% |
| 2013 | -20.0% | 40.0% |
| 2014 | 30.0% | 15.0% |

What is the Spearman rank correlation coefficient for stocks returns of X and Y?

A. -0.7

B. -0.5

C. 0.3



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D.　0.7

***Answer: A***

The following table illustrate the calculation used to determine the sum of squared ranking deviations:

| Year | X | Y | X Rank | Y Rank | $d_i$ | $d_i^2$ |
|---|---|---|---|---|---|---|
| 2013 | -20.0% | 40.0% | 1 | 5 | -4 | 16 |
| 2012 | -10.0% | 20.0% | 2 | 4 | -2 | 4 |
| 2010 | 5.0% | -10.0% | 3 | 1 | 2 | 4 |
| 2014 | 30.0% | 15.0% | 4 | 3 | 1 | 1 |
| 2011 | 50.0% | -5.0% | 5 | 2 | 3 | 9 |
| | | | | | Sum | 34 |

Thus, the Spearman rank correlation coefficient is -0.7:

$$\rho_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)} = 1 - \frac{6\times 34}{5(25-1)} = -0.7$$

**2.2** The annual returns of two assets, X(i) and Y(i), are shown below for the five years from 2010 to 2103. The returns have been sorted with respect to X(i); for example, in 2010 X(i) returned 6.0% which ranked 4th among its annual returns (ranking is from worst to best). The Pearson correlation coefficient, taken from the actual return pairs - for example, (X, Y) = (-12.5%, 4.3%) - is about 0.756. But we are interested instead in a rank correlation. Which is nearest to the Spearman's rank correlation?

| Year | Ranked Return of X(i) | Assigned (same year) Return of Y(i) |
|---|---|---|
| 2013 | -12.5% | 4.3% |
| 2011 | -9.6% | 2.5% |
| 2010 | 4.3% | 6.0% |
| 2014 | 8.7% | 6.2% |
| 2012 | 16.0% | 5.5% |

A.　0.25

B.　0.33

C.　0.60

D.　0.85



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***Answer: C***

Spearman's rank correlation = 1 - (6 × [sum of $d(i)^2$]/[$n(n^2-1)$] = 1 - (6 × 8)/[5 × ($5^2$ - 1)] = 1 - 48/120 = 0.60

**2.3** About correlation measures including Pearson's, Spearman's and Kendall's tau, each of the following is true accept which is false?

A. Pearson is a cardinal correlation measure while Spearman's and Kendall's tau are ordinal correlation measures.

B. The problem with applying ordinal rank correlations to cardinal observations is that ordinal correlation are less sensitive to outliers (an unwelcome property in risk management)

C. An advantage of Pearson's correlation coefficient is that it is invariance to transformations: e.g., Pearson's correlation between pairs [x, y] will equal Pearson's correlation between [ln(x), ln(y)]

D. Pearson's correlation coefficient is a natural (good) dependence measure when variables are distributed as multivariate elliptical (e.g., normal, student's t); however, we know many financial variables are not elliptically distributed.

***Answer: C***

False. Pearson's is strictly not invariant to transformation. For example, Pearson's correlation between pairs [x, y] will not equal Pearson's between[ln(x), ln(y)]. In regard to (A), (B) and (D), each is TRUE.



**2.4** A risk manager is using a copula correlation model to perform stress tests of financial risk during systemic economic crises. If the risk manager is concerned about extreme outliers, which of the following correlation coefficient measures should be used?

A. Kendall's τ correlation

B. Ordinal correlation

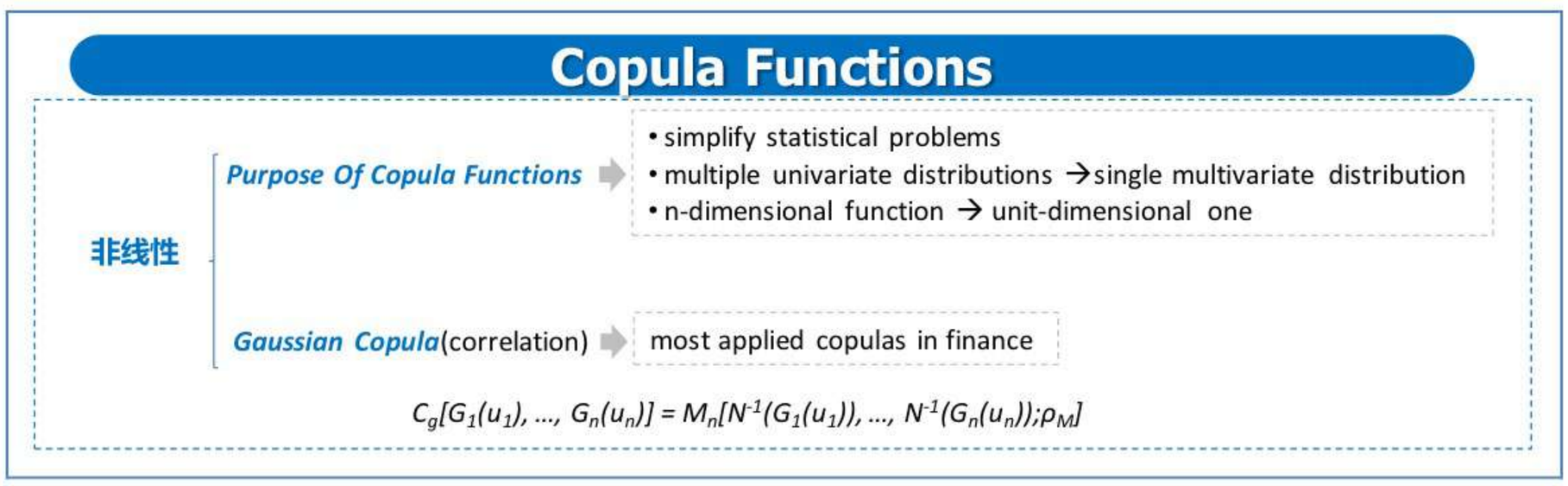
C. Pearson correlation

D. Spearman's rank correlation

***Answer: C***

The Pearson correlation coefficient is preferred to ordinal measures when outliers are a concern. Spearman's rank correlation and Kendall's τ are ordinal correlation coefficients that should not be used with cardinal financial variables because they underestimate risk by ignoring the impact of outliers.

## 3 Copula Functions




**3.1** Which of the following statements about correlation and copula are correct?

I.Copula enables the structures of correlation between variables to be calculated separately from their marginal distributions.

II.Transformation of variables does not change their correlation structure.

III.Correlation can be a useful measure of the relationship between variables drawn from a distribution without a defined variance.

IV.Correlation s a good measure of dependence when the measured variables are distributed as multivariate elliptical.

A. I and IV only

B. II, III, and IV only

C. I and III only

D. II and IV only

***Answer: A***

"I" is true. Using the copula approach, we can calculate the structures of correlation between variables separately from the marginal distributions. "IV" is also true. Correlation is a good measure of dependence when the measured variables are distributed as multivariate elliptical.

"II" is false. The correlation between transformed variables will not always be the same as the correlation between those same variables before transformation. Data transformation can sometimes alter the correlation estimate. "III" is also false. Correlation is not defined unless variances are finite.

**3.2** The dependence structure between the returns of financial assets plays an important role in risk measurement. For liquid markets, which of the following statements is incorrect? (Important)

A. Correlation is a valid measure of dependence between random variables for only certain types of return distributions.

B. Even if the return distributions of two assets have a correlation of zero, the returns of these assets are not necessarily independent.

C. Copulas make it possible to model marginal distributions and the dependence structure separately.

D. Correlation estimates based on short lookback horizons (three months or less) are typically very stable.

***Answer: D***

# 6 The Science Of Term Structure Models

## 1 Measures of Pricing Sensitivity Based on Parallel Yield Shifts

**Bond Valuation**

***Discounted Future CF*** ➡ $P=\sum_{t=1}^{n}\frac{\text{cash flow}_t}{(1+\text{discount rate})^t}$

***Interest rate risk*** → ***Duration***: bond's interest rate risk or sensitivity of a bond's full price to a change in its yield

★ ***Macaulay Duration:*** the average time to wait for each payment, weighted by PV of cash flow

$$Macaulay\ duration=\sum_{t=1}^{n}[t\times(PVCF_t/P_0)]$$

***Yield-Based DV01*** ➡ DV01=Duration × Bond Value ×0.0001=D* ×P × 0.0001 ➡ $DV01=-\frac{1}{10,000}\times\frac{dP}{dy}$

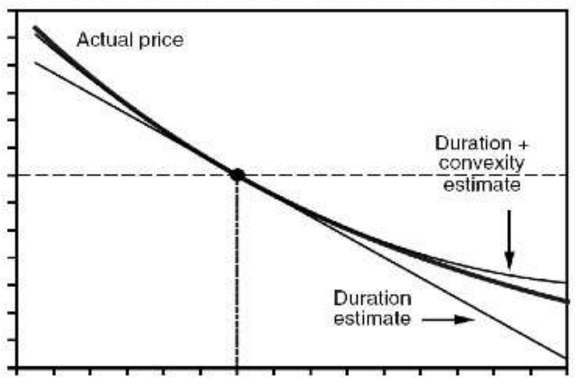
***Yield-Based Convexity*** ➡
- Convexity is always positive for regular coupon-paying bonds
- Greater convexity is beneficial both for falling and rising yields

***All else equal, duration and convexity both increase for*** ★
- longer maturities(夜长梦多)
- lower coupons(财大气粗)
- lower yields(看斜率)



**Bond Valuation**

★ ***Bond Price and Yield*** ➡
- Using Duration only: $\Delta P=-D^*\times P\times\Delta y$
- Using Duration and Convexity: $\Delta P=-D^*\times P\times\Delta y+\frac{1}{2}\times C\times P\times(\Delta y)^2$




★ ***The Barbell vs. The Bullet*** ➡
- ***barbell bond portfolio***: short maturities (low duration) + long maturities (high duration)
- ***bullet bond portfolio*** : concentrates in medium-term maturities

***With the same duration, barbell bond has larger convexity than bullet bond***

**1.1** John Snows portfolio has a fixed-income position with market value of USD 70 million with modified duration of 6.44 years and yielding 6.7% compounded semiannually. If there is a positive parallel shift in the yield curve of 25 basis points, which of the following answers best



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estimates the resulting change in the value of John's portfolio?

A. USD -11,725

B. USD -1,127,000

C. USD -1,134,692

D. USD -1,164,755

***Answer: B***

A: is correct. By definition, $D_{mod}$ = (-I/P) (dP/dy). So as a linear approximation, $\Delta P = -D_{mod} \times P \times \Delta y = -6.44 \times 70 \text{ million} \times 0.0025 = -1,127,000$

**1.2** A bond portfolio consists of five bonds:

•Bond 1: 5%, annual-pay bond with a 10-year maturity and a yield of 4.5%.

•Bond 2: 5%, semiannual-pay bond with a 10-year maturity and a yield of 4.5%.

•Bond 3: A zero-coupon bond with a 10-year maturity and a yield of 4.5%.

•Bond 4: 4%, semiannual-pay bond with a 10-year maturity and a yield of 4.5%.

•Bond 5: 5%, annual-pay bond with a 10-year maturity and a yield of 5.5%.

Which of the following statements about these bonds is Correct?

A. Bond 1 has a shorter duration than Bond 2.

B. The Macaulay duration of Bond 3 is five years.

C. Bond 4 has a shorter duration than Bond 2.

D. The DV01 of Bond 5 is lower than the DV01 of Bond 1.

***Answer: D***

Choice D is correct. Increasing the yield will lower the DV01. Since Bond 5 has a higher yield than Bond 1, it must have a lower DV01. Choice B is incorrect. The Macaulay duration of a zero-coupon bond will be equal to its maturity Choices A and C are incorrect. All else equal, a semiannual-pay bond will have a shorter duration than an annual-pay bond, so Bond 2 has a shorter duration than Bond 1. A premium bond will have a shorter duration than a discount bond, so Bond 2 will have a shorter duration than Bond 4.

**1.3** Given the following bond portfolios:

| Bond Maturity | Portfolio I Duration Contribution | Portfolio 2 Duration Contribution |
|---|---|---|
| 2-year bonds | 1.32 | 0.52 |
| 5-year bonds | 1.37 | 3.18 |
| 10-year bonds | 3.95 | 1.05 |



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| | | |
|---|---|---|
| 20-year bonds | 1.51 | 3.40 |
| Effective portfolio duration | ? | ? |

Which of the following statements is correct?

A. Portfolio 1 is a barbell portfolio.

B. Portfolio 2 is a bullet portfolio.

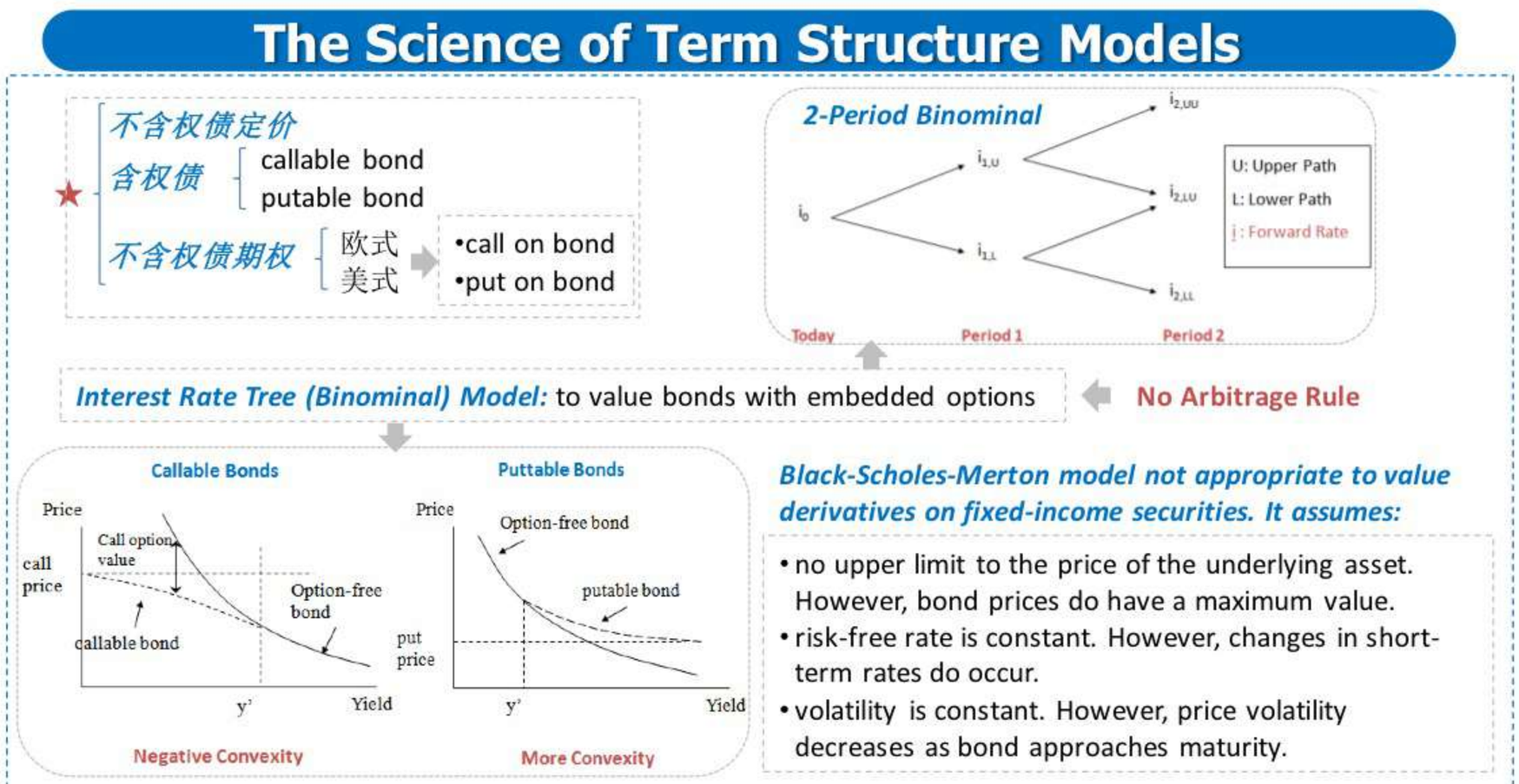
C. It is impossible for Portfolios 1 and 2 to have the same duration.

D. Portfolio 2 will have greater convexity than Portfolio 1.

***Answer: D***

Since Portfolio 2 has more long-term bonds than short-term bonds and since convexity is related to the square of maturity, Portfolio 2 will have greater convexity. The other statements are incorrect. Portfolio 1 is a bullet portfolio (concentrated in intermediate maturities), and Portfolio 2 is a barbell. It is possible for a bullet and a barbell to have the same duration. In fact, adding the duration contribution of both portfolios gives a duration value of 8.15.

## 2 Interest Rate Tree (Binominal) Model




**2.1** Suppose investors have interest rate expectations as illustrated in the decision tree below where the 1-year rate is expected to be 8%, 6%, or 4% in the second year and either 7% or 5% in the first year for a zero-coupon bond.



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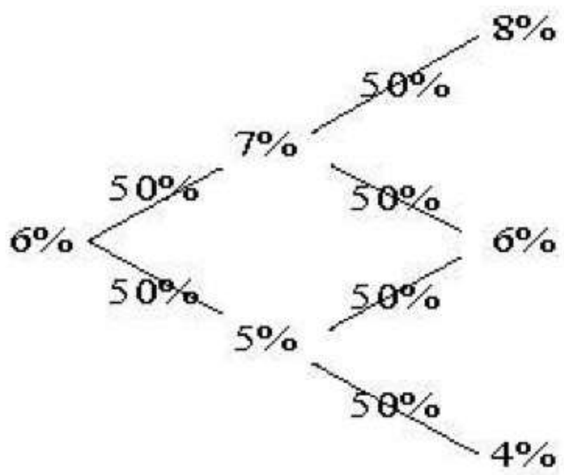


If investors are risk-neutral, what is the price of a $1 face value 2-year zero-coupon bond today?

A. $0.88113

B. $0.88634

C. $0.89007

D. $0.89032

***Answer: C***

$$\left(\frac{1}{1+7\%}\times 50\%+\frac{1}{1+5\%}\times 50\%\right)\Big/(1+6\%)=0.89007$$

**2.2** A European put option has two years to expiration and a strike price of $101.00. The underlying is a 7% annual coupon bond with three years to maturity. Assume that the risk-neutral probability of an up move is 0.76 in year 1 and 0.60 in year 2. The current interest rate is 3.00%. At the end of year 1, the rate will either be 5.99% or 4.44%. If the rate in year 1 is 5.99%, it will either rise to 8.56% or rise to 6.34% in year 2. If the rate in one year is 4.44%, it will either rise to 6.34% or rise to 4.70%. The value of the put option today is closet to:

A. $1.17

B. $1.30

C. $1.49

D. $1.98

***Answer: A***

This is the same underlying bond and interest rate tree as in the call option example from this topic. However, here we are valuing a put option.

The option value in the upper node at the end of year 1 is computed as:

$$\frac{(\$2.44\times 0.6)+(\$0.38\times 0.4)}{1.0599}=\$1.52$$

The option value in the lower node at the end of year 1 is computed as:

$$\frac{(\$0.38\times 0.6)+(\$0.00\times 0.4)}{1.0444}=\$0.22$$



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The option value today is computed as:

$$\frac{(\$1.52 \times 0.76) + (\$0.22 \times 0.24)}{1.0300} = \$1.17$$

**2.3** A risk manager is pricing a 10-year call option on 10-year Treasury using a successfully tested pricing model. Current interest rate volatility is high and the risk manager is concerned about the effect this may have on short-term rates when pricing the option. Which of the following actions would best address the potential for negative short-term interest rates to arise in themodel?(Practice Exam)

A. The risk manager uses a normal distribution of interest rates.

B. When short-term rates are negative, the risk manager adjusts the risk-neutral probabilities.

C. When short-term rates are negative, the risk manager increases the volatility.

D. When short-term rates are negative, the risk manager sets the rate to zero.

***Correct answer: d***

**Explanation:** Negative short-term interest rates can arise in models for which the terminal distribution of interest rates follows a normal distribution. The existence of negative interest rates does not make much economic sensesince market participants would generally not lend cash at negative interest rates when they can hold cash and earn a zero return. One method that can be used to address the potential for negative interest rates when constructing interest rate trees is to set all negative interest rates to zero. This localizes the change in assumption s to points in the distribution corresponding to negative interestrates and preserves the original rate tree for all other observations. Incomparison, adjusting the risk neutral probabilities would alter the dynamics across the entire range of interest rates and therefore not be an optimal approach.

When a model displays the potential for negative short-term interestrates, it can still be a desirable model to use in certain situations, especially in cases where the valuation depends more on the average path of the interest rate, such as in valuing coupon bonds. Therefore, the potential for negative rates does not automaticallyruleouttheuseofthemodel.

**2.4** A 2-year zero-coupon bond with a face value of USD 1,000 is currently priced at USD 952.48. The firm uses a binominal pricing model with a 1-year time step for all of its valuations. If interest rates go down over the next year, the model estimates the bond's value to be USD 970, and if interest rates go up over the next year, the model estimates the bond's value to be SUD 950. Using the risk-neutral probabilities implied by the model, and assuming the risk-free rate of interest is 1% per year, what should be the current value of a 1-year European call option on this bond with a strike price of USD 960? (Important)

A. USD 3.96

B. USD 5.94



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C. USD 6.00

D. USD 9.90

***Answer: B***

## 3 Term Structure Models

### The Shape of The Term Structure

| Theory | Details |
|---|---|
| Pure Expectation | forward rates are solely a function of expected future spot rates<br>不足: fail to consider the riskiness of bond investing |
| Liquidity Preference | forward rates are biased estimates of the market's expectation of future rates include liquidity premium |
| Market Segmentation | • shape of the yield curve→ preferences of borrowers and lenders<br>• Yield at each maturity is determined independently |
| Preferred habitat | • forward rates represent expected future spot rates plus a premium(not related to maturity)<br>• explain almost any yield curve shape |

***Interest Rate Volatility:*** volatility of expected rates causes the future spot rates to be lower

★ Convexity Effect(Jensen's inequality) $E\left[\frac{1}{(1+r)}\right] > \frac{1}{E[1+r]}$

the value of convexity increases with maturity and volatility

### The Art of Term Structure Models: Drift

★计算

***Model 1 (no Drift)*** $dr = \varepsilon\sigma\sqrt{dt}$

***Trend***

- ***Model 2 (with Drift)*** $dr = \lambda dt + \varepsilon\sigma\sqrt{dt}$
- ***Ho-Lee Model (with time-dependent drift)*** $dr = \lambda(t)dt + \varepsilon\sigma\sqrt{dt}$

***mean reverting*** → ***Vasicek Model*** ★ $dr = k(\theta - r)dt + \varepsilon\sigma\sqrt{dt}$

k=a parameter that measures the speed of reversion adjustment
$\theta$=long-run value of the short-term rate assuming risk neutrality
r=current interest rate level

Assuming a long-run interest rate of $r_L$, then long-run mean reverting level is: $\theta \approx r_L + \frac{\lambda}{k}$

***Model 3 (with time-dependent volatility )*** $dr = \lambda(t) + \varepsilon\sigma e^{-\alpha t}\sqrt{dt}$

***Cox-Ingersoll-Ross (CIR) Model*** $dr = k(\theta - r)dt + \sigma\sqrt{r}\varepsilon\sqrt{dt}$ σ与r相关

***Model 4 (Lognormal)*** $dr = ardt + \sigma r\varepsilon\sqrt{dt}$ →

$d[\ln(r)] = a(t)dt + \sigma\varepsilon\sqrt{dt}$

$d[\ln(r)] = k(t)[\ln\theta(t) - \ln(r)]dt + \sigma(t)\varepsilon\sqrt{dt}$

结论★

- Ho-Lee model, the drift terms are ***additive***
- Lognormal model, the drift terms are ***multiplicative***

**3.1** Model 1 assumes zero drift and is also called a normal model. Model 2 add a term for drift. Each of the following is true about these two models except for:

A. A weakness of Model 1 is that the short-term rate can become negative.



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B. Model 1 implies a term structure that is perfectly flat at the current rate for all maturities, including the long-term rates.

C. Model 2 is more capable of producing an upward-sloping term structure, which is often observed.

D. Model 2 is an equilibrium model, rather than an arbitrage-free model, because no attempt is made to match the term structure closely.

***Answer: B***

Under Model 1, it is true that the middle node recombines to the same current node. But these are future short-term rates; they are not the term structure: the term structure is spot rates at all maturities. Models that take the initial term structure implied by market prices are called arbitrage-free models. A different approach, however, is to start with assumptions about the interest rate process and about the risk premium demanded by the market for bearing interest rate risk and then derive the risk-neutral process. Models of this sort do not necessarily match the initial term structure and are called equilibrium models.

**3.2** John Jones, FRM, is discussing the appropriate usage of mean-reverting models relative to no-drift models, models that incorporate drift, and Ho-Lee models. Jones makes the following statements:

Statement 1: Both Model 1 (no drift) and the Vasicek model assume parallel shifts from changes in the short-term rate.

Statement 2: The Vasicek model assumes decreasing volatility of future short-term rates while Model 1 assumes constant volatility of future short-term rates.

Statement 3: The constant drift model (Model 2) is a more flexible model than the Ho-Lee model.

How many of his statements are correct?

A. 0

B. 1

C. 2

D. 3

***Answer: B***

Only statement 2 is correct. The Vasicek model implies decreasing volatility and non-parallel shifts from changes in short-term rates. The Ho-Lee model is actually more general than Model 2 (the no drift and constant drift models are special cases of the Ho-Lee model).

**3.3** Using Model 1, assume the current short-term interest rate is 5%, annual volatility is 80bps,

and dω, a normally distribution random variable with mean 0 and standard deviation$\sqrt{dt}$, has an



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expected value of zero. After one month, the realization of dω is -0.5. What is the change in the spot rate and the new spot rate?

Change in Spot　New Spot Rate

A. A. 0.40%　5.40%

B. B. -0.40%　4.60%

C. C. 0.80%　5.80%

D. D. -0.80%　4.20%

***Answer: B***

Model 1 has a no-drift assumption. Using this model, the change in the interest rate is predicted as:

$$dr = \sigma d\omega$$
$$dr = 0.8\% \times (-0.5) = -0.4\% = -40 \text{ basis points}$$

Since the initial rate was 5% and dr = -0.40%, the new spot rate in one month is:

5% - 0.40% = 4.60%

**3.4** An analyst is modeling spot rate changes using short rate term structure models. The current short-term interest rate is 5% with a volatility of 80 bps. After one month passes the realization of dω, a normally distributed random variable with mean 0 and standard deviation $\sqrt{dt}$, is -0.5. Assume a constant interest rate drift, λ, of 0.36%. What should the analyst compute as the new spot rate?

A. 5.37%

B. 4.63%

C. 5.76%

D. 4.24%

***Answer: B***

This short rate process has an annualized drift of 0.36%, so it requires the use of Model 2 (with constant drift). The change in the spot rate is computed as:

$$dr = \lambda dt + \sigma d\omega$$
$$dr = (0.36\% / 12) + (0.8\% \times -0.5) = -0.37\% = -37 \text{bps}$$

Since the initial short-term rate was 5% and dr is -0.37%, the new spot rate in one month is:

5% - 0.37% = 4.63%



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**3.5** A risk manager is constructing a term structure model and intends to use the Cox-Ingersoll-Roll model. Which of the following describes this model? (Practice Exam)

A. The model presumes that the volatility of the short rate will increase at a predetermined rate.

B. The model presumes that the volatility of the short rate will decline exponentially to a constant level.

C. The model presumes that the basis-point volatility of the short rate will be proportional to the rate.

D. The model presumes that the basis-point volatility of the short rate will be proportional to the square root of the rate.

***Answer: D***

In the CIR model, the basis-point volatility of the short rate is not independent of the short rate as other simpler models assume. The annualized basis-point volatility equals $\sigma\sqrt{r}$ and therefore increases as a function of the square root of the rate.

**3.6** An investor expects the current 1-year rate for a zero-coupon bond to remain at 6%, the 1-year rate next year to be 8%, and the 1-year rate in two years to be 10%. What is the 3-year spot rate for zero-coupon bond with face value of $1, assuming all investor have the same expectations of future 1-year rates for zero-coupon bonds?

A. 7.888%

B. 7.98%

C. 8.000%

D. 8.088%

***Answer: B***

The 3-year spot rate can be solved for using the following equation:

$$\frac{\$1}{(1.06)(1.08)(1.10)} = \frac{\$1}{(1+r(3))^3}$$

$$r(3) = \sqrt[3]{(1.06)(1.08)(1.10)} - 1 = 7.988\%$$

**3.7** Suppose an investor expects that 1-year rate will remain at 6% for the first year for a 2-year zero-coupon bond. The investor also projects a 50% probability that the 1-year spot rate will be 4% or 8% in one year. Which of the following inequalities most accurately reflects the convexity for this 2-year bond using Jensen's inequality formula?

A. $0.89031 > $0.89000

B. $0.89000 > $0.80000



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C. $0.94340 > $0.89031

D. $0.94373 > $0.94340

***Answer: A***

The left-hand side of Jensen's inequality is the expected price in one year using the 1-year spot rates of 8% and 4%.

$$E\left(\frac{\$1}{(1+r)}\right)=0.5\times\frac{\$1}{(1.08)}+0.5\times\frac{\$1}{(1.04)}=0.5\times0.92593+0.5\times0.96154=0.94373$$

The expected price in one year using an expected rate of 6% computes the right-hand side of the inequality as:

$$\frac{\$0.94373}{0.5\times1.08+0.5\times1.04}=\frac{\$1}{1.06}=0.94340$$

Next, divide each side of the equation by 1.06 to discount 1-year zero-coupon bond price for one more year at 6%. The price of the 2-year zero-coupon bond equals $0.89031(calculated as 0.94373/1.06), which is greater than $0.89000 (the price of a 2-year zero-coupon bond discounted for two years at the expected rate of 6%). Thus, Jensen's inequality reveal that $0.89031 > $0.89000.

**3.8** Which of the following statements best characterizes the differences between the Ho-Lee model with drift and the lognormal model with drift?

A. In the Ho-Lee model and the lognormal model the drift terms are multiplicative.

B. In the Ho-Lee model and the lognormal model the drift terms are additive

C. In the Ho-Lee model the drift terms are multiplicative, but in the lognormal model the drift terms are additive

D. In the Ho-Lee model the drift terms are additive, but in the lognormal model the drift terms are multiplicative.

***Answer: D***

The Ho-Lee model with drift is very flexible, allowing the drift terms each period to vary. Hence, the cumulative effect is additive. In contrast, the lognormal model with drift allows the drift terms to vary, but the cumulative effect is multiplicative.

**3.9** An analyst is looking at various models used to incorporate drift into term structure models. The Ho-Lee Model: (Practice Exam)

A. Incorporates no-risk premium to the interest rate model allowing rates to vary according to their volatility.

B. Incorporates drift as a premium to interest rates that remains constant over time.



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C. Allows for a risk premium to be applied to interest rates that changes over time.

D. Incorporates drift into the model following the assumption that rates revert to the long-run equilibrium value.

***Answer: C***

Choice C is correct: the Ho-Lee model incorporates a premium to each rate change that can be different at each point in time.

**3.10** In the past few years, the markets have experienced very low interest rates, in some rare cases below zero. A risk manager is selecting an interest rate model which should reflect the following properties: (Important)

- Negative values should revert to a mean rate.
- The tree should be recombining to make computation feasible.
- The rates should be able to move between positive and negative values.

After researching various models, which of the following is most appropriate?

A. Black-Karasinski model.

B. Vasicek model.

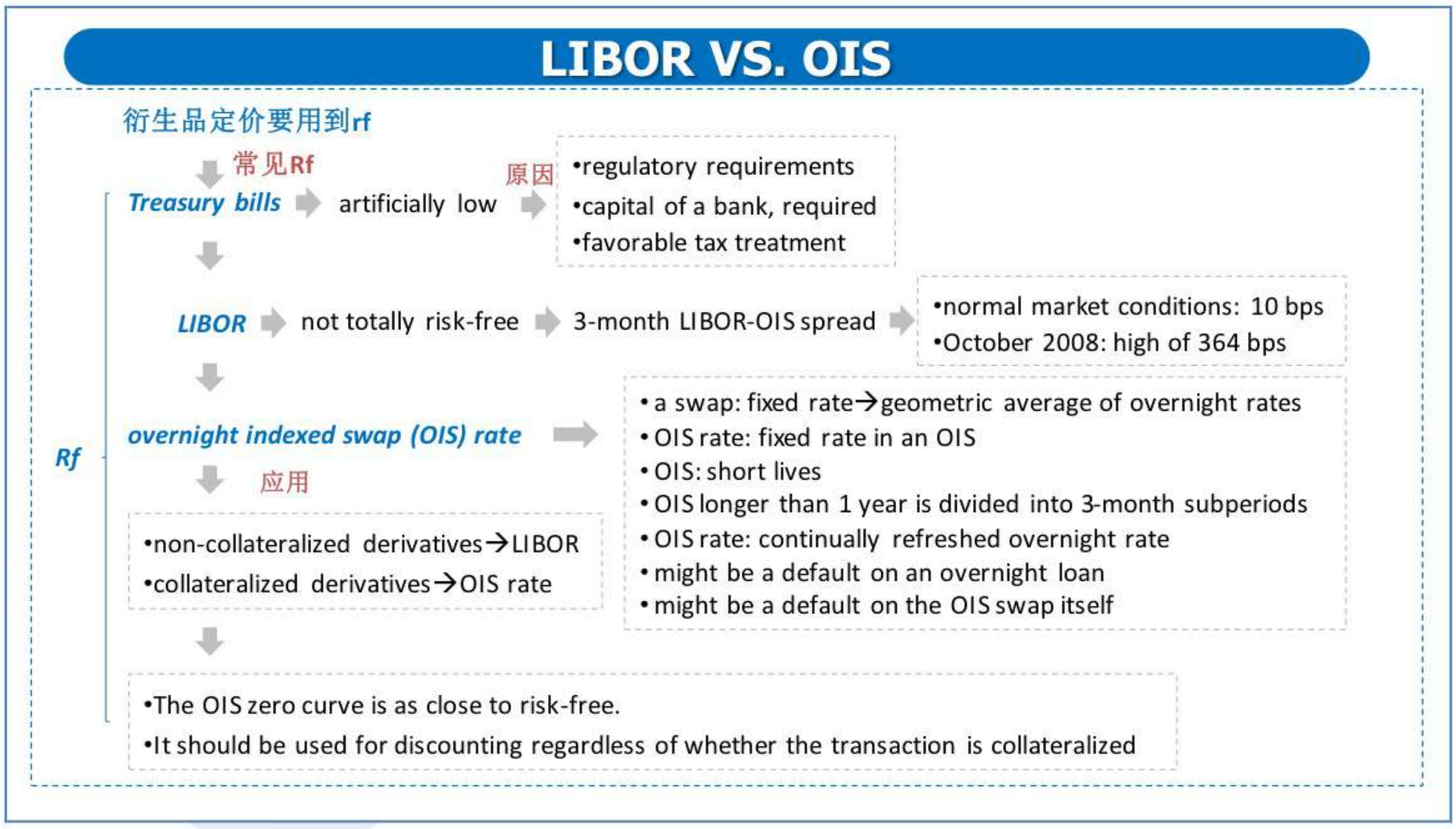
C. Ho-Lee model.

D. Constant drift model.

***Answer: B***

# 7 LIBOR VS. OIS

## 1 Discount Rate Selection






**1.1** The current edition of the monthly research report of an investment bank is dedicated to discussing the risk-free rate and contains the following statements:

"In the United States, rates of Treasury securities may not be considered the best proxy for a risk-free rate because financial institutions are required to purchase Treasury securities due to various regulatory requirements, which may result in an artificially low yield for these securities. Another proxy for the risk-free rate is LIBOR, which has been increasingly used in collateralized transactions following 2007-2009 financial crisis."

With respect to Treasury securities and LIBOR, are these statements considered accurate?

| | Treasury securities | LIBOR |
|---|---|---|
| A | No | No |
| B | No | Yes |
| C | Yes | Yes |
| D | Yes | No |

***Answer: D***

Only the first statement is correct. The second statement is incorrect because LIBOR has been



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increasingly used in non-collateralized transactions following the 2007-2009 financial crisis.

**1.2** An analyst notes in a presentation to management that the U.S. three-month LIBOR-OIS spread declined from 150 basis points a year ago to 80 basis points today. Regarding this scenario, which of the following statements is considered most accurate?

A. The decline in spread represents a decline in credit quality in the markets.

B. A payment of 80 basis points must be made by the floating-rate payer of the OIS.

C. The LIBOR rate is now a better proxy for the risk-free rate than the OIS rate.

D. Stress in the financial markets has declined.

***Answer: D***

The LIBOR-OIS spread is used as a measure of stress in financial markets. A decline in the spread indicates a decline in stress, or an improvement in credit quality, in markets. The spread is not a measure of payment on an overnight indexed swap. The spread also does not imply that the LIBOR rate would be superior to the OIS rate as a proxy for the risk-free rate.

**1.3** Mikey Parizeau, FRM, is a fixed income analyze at a large financial institution. Parizeau states to a colleague that while the OIS rate is not entirely risk-free, it is considered the best proxy for the risk-free rate when used in valuing collateralized derivatives. Is Parizcau's observation correct?

A. Yes.

B. No, because the OIS rate is considered entirely risk-free.

C. No, because the OIS rate is considered the best proxy for the risk-free rate for valuing both collateralized and non-collateralized derivatives.

D. No, because the OIS rate is considered the best proxy for the risk-free rate for valuing only non-collateralized derivatives.

***Answer: A***

Parizeau s statement is correct. Although the OIS rate is not entirely risk-free, it is considered the best proxy for the risk-free rate to be used in valuing collateralized derivatives because the OIS rate provides a good estimate of the funding cost of collateral. LIBOR rates continue to be used for valuing non-collateralized derivatives.

**1.4** Assume that the one-, two- and three-year LIBOR-for-fixed swaps trade at a spread of 15, 18, and 20 basis points, respectively, above the corresponding OISs. If the 10-year LIBOR-for-fixed swap rate is 4.5%, what is the best estimate for the 10-year OIS rate?

A. 0.2%

B. 4.3%

C. 4.5%



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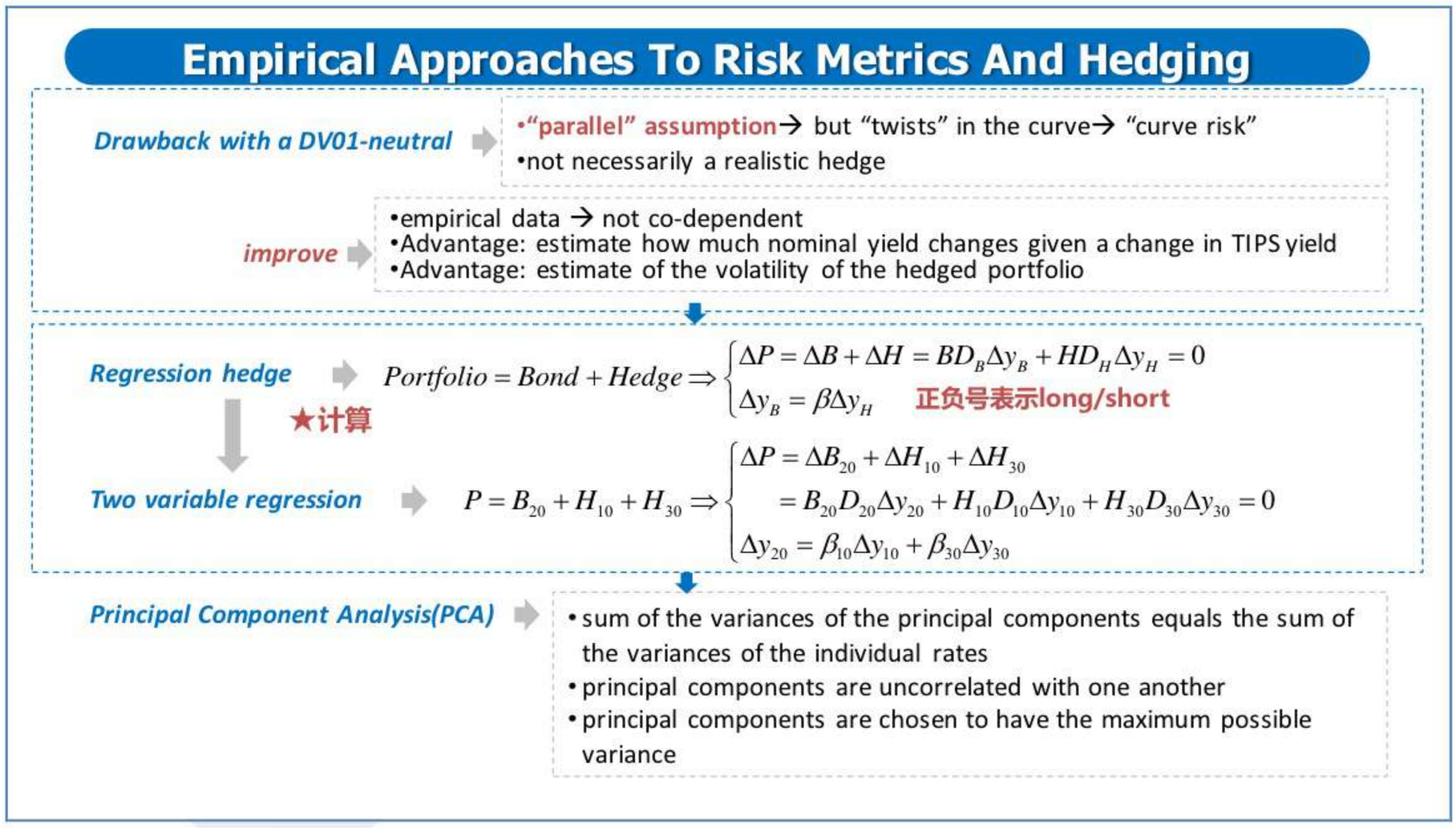
D.　4.7%

***Answer: B***

It is common for OISs not to trade for maturities that are as long as LIBOR-for-fixed swaps. Given a lack of" reliable data for OIS maturities beyond three years in our example, a common approach is to assume that the spread (between the LIBOR swap rate and the OIS rate for the longest maturity with reliable data) remains constant for all longer maturities. As a result, all OIS rates beyond three years are assumed to be 20 basis points below LIBOR swap rates. The best estimate of the 10-year OIS rate is therefore 4.5% - 0.2% = 4.3%.

# 8 Empirical Approaches To Risk Metrics And Hedging

## 1　Key Point: Empirical Approaches to Risk Metrics and Hedge






**1.1** Assume that a trader is making a relative value trade, selling a U.S. Treasury bond and correspondingly purchasing a U.S. Treasury TIPS. Based on the current spread between the two securities, the trader shorts $100 million of the nominal bond and purchases $89.8 million of TIPS. The trader then starts to question the amount of the hedge due to changes in yields on TIPS in relation to nominal bonds. He runs a regression and determines from the output that the nominal yield changes by 1.0274 basis points per basis point change in the real yield. Would the trader adjust the hedge, and if so, by how much?

A. No

B. Yes, by $2.46 million (purchase additional TIPS).

C. Yes, by $2.5 million (sell a portion of the TIPS).

D. Yes, by $2.11 million (purchase additional TIPS)

***Answer: B***

The trader would need to adjust hedge as follows:

$89.8 million × 1.0274 = $92.26 million

Thus, the trader needs to purchase additional TIPS worth $2.46 million.



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**1.2** Assume that a trader wishes to set up a hedge such that he sells $100,000 of a Treasury bond and buys Treasury TIPS as a hedge. Using a historical yield regression framework, assume the DV01 on the T-bond is 0.072, the DV01 on the TIPS is 0.051, and the hedge adjustment factor (regression beta coefficient) is 1.2. What is the face value of the offsetting TIPS position needed to carry out this regression hedge?

A. $138,462

B. $169,412

C. $268,499

D. $280,067

***Answer: B***

Defining $F_R$ and as $F_N$ the face amounts of the real and nominal bonds, respectively, and their corresponding DV01 as $DV01_R$ and $DV01_N$, a DV01 hedge is adjusted by the hedge adjustment factor, or beta, as follow:

$$F^R = F^N \times \left[\frac{DV01^N}{DV01^R}\right] \times \beta$$

$$F^R = 100{,}000 \times \left[\frac{0.072}{0.051}\right] \times 1.2 = 169{,}412$$

# 9 Volatility Smiles

## 1　Key Point: Volatility Smile

### What Is Volatility Smiles

***Volatility smile :*** a plot of the ***implied volatility*** of an option as a function of its ***strike price***

***Put-Call Parity***(whatever pricing model is used): $p+S_0e^{-qT}=c+Xe^{-rT}$

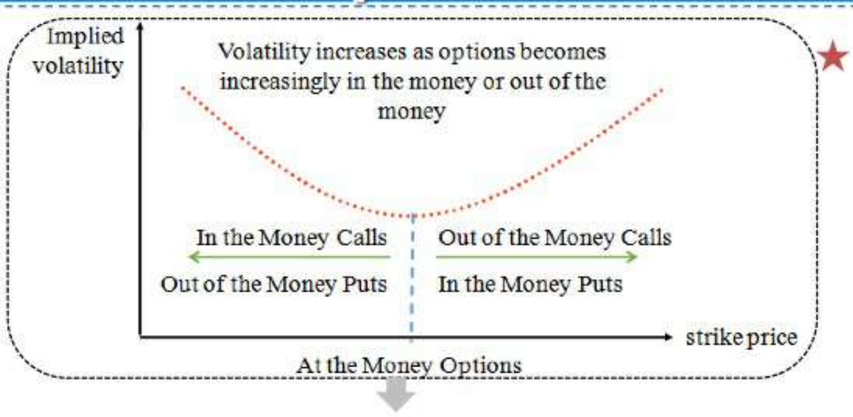
★ The implied volatility of a European call option is always the same as the implied volatility of a European put option
(when the two have the same strike price and maturity date)

了解

***Alternative ways of characterizing the volatility smile***

- strike price(K)→$K/S_0$→ $K/F_0$ ($F_0$: the forward pirce of the asset)
- strike price(K)→delta of the option

### Volatility Smile For Foreign Currency Options



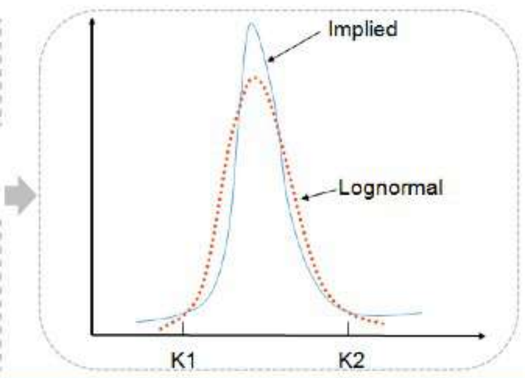

★

***Contidions for an asset price to have a lognormal distribution***

- The volatility of the asset is constant
- The price of the asset changes smoothly with no jumps

***Exchange rate is not lognormally distributed***

- In practice, neither of these conditions is satisfied for an exchange rate.
- The volatility of an exchange rate is far from constant, and exchange rates frequently exhibit jumps



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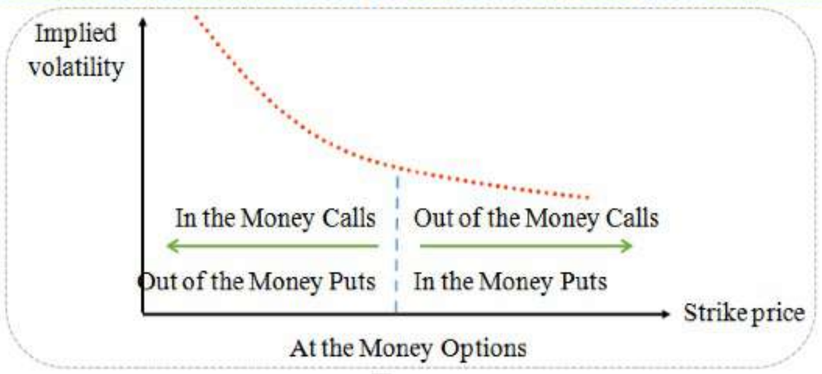
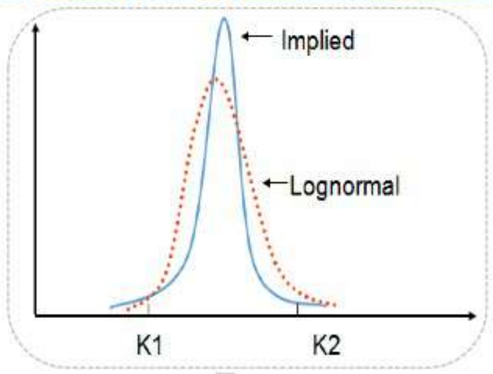
## Volatility Smiles (Skew) For Equity Options




★左高右低




***Reasons For The Smile In Equity Options***

- ***Leverage***: firm's equity value decreases→leverage increases→increases the riskness/volatility of the underlying assets
- ***Crashophobia***: 1987 stock market crash→higher premiums for put prices when the strike prices lower

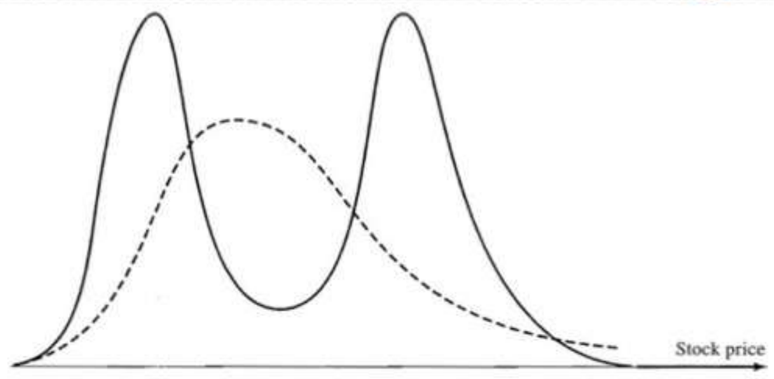
The implied distribution has a heavier left tail and a less heavy right tail than the lognormal distribution.

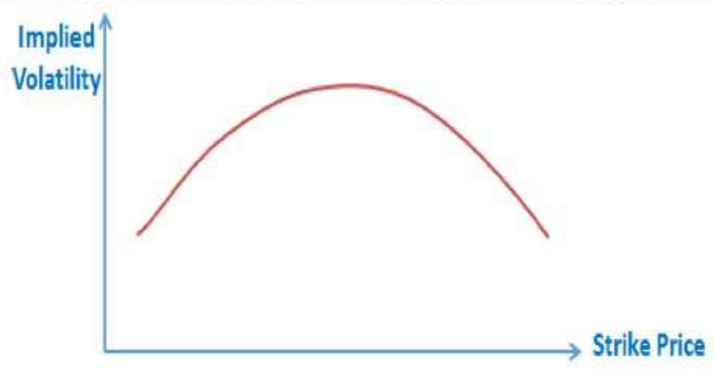
- Traders allow the implied volatility to depend on time to maturity as well as strike price.
- Volatility surfaces combine volatility smiles with the time to maturity and K/S0.

## The Impact Of Large Asset Price Jumps

Implied volatility is affected by price jumps and the probabilities assumed for either a large up or down movement

- ***At-the-money options*** tend to have a higher implied volatility than either out-of-the-money or in-the-money options
- Away-from-the-money options exhibit a lower implied volatility than at-the-money options




**1.1** The Chief Risk Officer of Martingale Investments Group is planning a change in methodology for some of the risk management models used to estimate risk measures. His aim is to move from models that use the normal distribution of returns to models that use the distribution of returns implied by market prices. Martingale Group has a large long position in the German equity stock index DAX which has a volatility smile that slopes downward to the right. How will the change in methodology affect the estimate of expected shortfall (ES)?

A. ES with the updated models will be larger than the old estimate.

B. ES with the updated models will be smaller than the old estimate.

C. ES will remain unchanged.



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D. Insufficient information to determine.

***Answer: A***

A volatility smile is a common graphical shape that results from plotting the strike price and implied volatility of a group of options with the same expiration date. Since the volatility smile is downward sloping to the right, the implied distribution has a fatter left tail compared to the lognormal distribution of returns. This means that an extreme decrease in the DAX has a higher probability of occurrence under the implied distribution than the lognormal. The ES will therefore be larger when the methodology is modified.

**1.2** With all other things being equal, a risk monitoring system that assumes constant volatility for equity returns will understate the implied volatility for which of the following positions by the largest amount:

A. Short position in an at-the-money call

B. Long position in an at-the-money call

C. Short position in a deep in-the-money call

D. Long position in a deep in-the-money call

***Answer: D***

A plot of the implied volatility of an option as a function of its strike price demonstrates a pattern known as the volatility smile or volatility skew. The implied volatility decreases as the strike price increases. Thus, all else equal, a risk monitoring system which assumes constant volatility for equity returns will understate the implied volatility for a long position in a deep-in-the-money call.

**1.3** Which of the following regarding equity option volatility is true?

A. There is higher implied price volatility for away-from-the-money equity options.

B. "Crashophobia" suggests actual equity volatility increases when stock prices decline.

C. Compared to the lognormal distribution, traders believe the probability of large down movements in price is similar to large up movements.

D. Increasing leverage at lower equity prices suggests increasing volatility.

***Answer: D***

There is higher implied price volatility for low strike price equity options. "Crashophobia" is based on the idea that large price declines are more likely than assumed in Black-Scholes-Merton prices, not that volatility increases when prices decline. Compared to the lognormal distribution, traders believe the probability of large down movements in price is higher than large up movements. Increasing leverage at lower equity prices suggests increasing volatility.

**1.4** You are asked to mark to market a book of plain vanilla stock options. The trader is short



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deep out-of-money options and long at-the-money options. There is a pronounced smile for these options. The trader's bonus increases as the value of his book increases. Which approach should you use to mark the book?

A. Use the implied volatility of at-the-money options because the estimation of the volatility is more reliable.

B. Use the average of the implied volatilities for the traded options for which you have data because all options should have the same implied volatility with Black-Scholes and you don't know which one is the right one.

C. For each option, use the implied volatility of the most similar option traded on the market.

D. Use the historical volatility because doing so corrects for the pricing mistakes in the option market.

***Answer: C***

The prices obtained with C are the right ones because they correspond to prices at which you could sell or buy the options.

**1.5** The market price of a European call is $3.00 and its Black-Scholes price is $3.50.The Black-Scholes price of a European put option with the same strike price and time to maturity is $2.00.What should the market price of this option be?

A. $1.50

B. $2.00

C. $1.00

D. $0.50

***Answer: A***

Based on the put-call parity, $c_{bs}+ Ke^{-rT}= p_{bs}+ S_0e^{-qT}$ and $c_{mkt}+ Ke^{-rT}= p_{mkt}+ S_0e^{-qT}$

We can know that:

$c_{bs}- c_{mkt}= p_{bs}- p_{mkt}$

And $c_{bs}= \$3.50$, $c_{mkt}= \$3.00$, $p_{bs}= \$2.00$.

So $p_{mkt}= \$1.50$.

Choose A

**1.6** An empirical distribution of equity price derived from the price of options of such stock based on BSM that exhibits a fatter right tail than that of a lognormal distribution would indicate:

A. Equal implied volatilities across low and high strike prices.

B. Greater implied volatilities for low strike prices.

C. Greater implied volatilities for high strike prices.

D. Higher implied volatilities for mid-range strike prices.

***Answer: C***

Explanation: An empirical distribution with a fat right tail generates a higher implied volatility for higher strike prices due to the increased probability of observing high underlying asset prices.

**1.7** Which of the following statements is true regarding volatility similes?

I.Currency options exhibit volatility smiles because at the money options have higher implied volatility than away from the money options.

II.Volatility frowns result when jumps occur in asset prices.

III.Equity options exhibit a volatility smirk because low strike price options have greater implied volatility.

IV.Relative to currency traders, it appears that equity trader's expectations of extreme price movements are more asymmetric.

A. I and II

B. I and IV

C. II and III

D. II, III, and IV

***Answer: D***

**1.8** Compared to at-the-money currency options, out-of-the-money currency options exhibit which of the following volatility traits?

A. Lower implied volatility

B. A frown

C. A smirk

D. Higher implied volatility

***Answer: D***

Away-from-the-money currency options have greater implied volatility than at-the-money currency options, this pattern in a volatility smile.

**1.9** A risk manager is examining a firm's equity index option price assumptions. The observed volatility skew for a particular equity index slopes downward to the right. Compared to the lognormal distribution, the distribution of option prices on this index implied by the Black-Scholes-Merton (BSM) model would have: (Practice Exam)

A. A fat left tail and a thin right tail.



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B. A fat left tail and a fat right tail.

C. A thin left tail and a fat right tail.

D. A thin left tail and a thin right tail.

***Answer: A***

A downward sloping volatility skew indicates that out of the money puts are more expensive than predicted by the Black-Scholes-Merton model and out of the money calls are cheaper than expected predicted by the Black-Scholes-Merton model. The implied distribution has fat left tails and thin right tails.

**1.10** A committee of risk management practitioner discusses the difference between pricing deep out-of-the-money call options on FBX stock and pricing deep out-of-the-money call options on the EUR/JPY foreign exchange rate using the Black-Scholes-Merton (BSM) model. The practitioners price these options based on two distinct probability distributions of underlying asset prices at the option expiration date:

•A lognormal probability distribution

•An implied risk-neutral probability distribution obtained from the volatility smile for options of the same maturity

Using the lognormal instead of the implied risk-neutral probability distribution will tend to:

A. Price the option on FBX relatively high and price the option on EUR/JPY relatively low.

B. Price the option on FBX relatively low and price the option on EUR/JPY relatively high.

C. Price the option on FBX relatively low and price the option on EUR/JPY relatively high.

D. Price the option on FBX relatively high and price the option on EUR/JPY relatively high.

***Answer: A***

The implied distribution of the underlying equity prices derived using the general volatility smile of equity options has a heavier left tail and a less heavy right tail than a lognormal distribution of underlying prices. Therefore, using the lognormal distribution of prices causes deep-out-of-the-money call options on the underlying to be priced relatively high.

The implied distribution of underling foreign currency prices derived using the general volatility smile of foreign currency options has heavier tail than a lognormal distribution of underlying prices. Therefore, using the lognormal distribution of prices causes deep-out-of-the-money call options on the underlying to be priced relatively low.



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# 目录

# Risk Management and Investment Management

## 1 Portfolio Construction

### 1　Portfolio Construction Process

**Portfolio Construction Process**

*选定风险资产→Asset Allocation (马克维茨有效前沿)*

↓ 如何选择风险资产

***Portfolio Construction***

- Current Portfolio→**Certain**
- Alphas
- Covariance Estimates
- Transaction Costs
- Active Risk Aversion

**5个Input**

**Input 1: Refining Alphas**

***Motivation For Refining Alphas***

investor / manager → **Constraints→Refining Alphas解决构建组合的复杂性为题**

↓ *refine the alphas方法*

***Method 1: Scaling Technique***

**Alpha(a)=Volatility x IC x Score**

***Method 2: Trimming Technique***

- Delete alphas due to *questionable data*

***Method 3: Neutralization***

- ***Benchmark Neutralization***
- ***Cash-Neutral Alphas***→消除cash alpha
- ***Risk-Factor-Neutral Alphas***→消除基金经理运气导致的alpha



**Input 2: Active Risk Aversion**

***Risk Aversion***

$$Risk\ Aversion = \frac{IR}{2 \times \varphi_P}$$

确定risk aversion很重要 → ***Reason***

- 帮基金经理意识到***huge losses***
- ***appropriate aversion risk factors***

**Input 3: Transaction Costs**

***Alpha*** — ***Active risk→one dimension***; ***Cost→Two dimension***

↓

***Transaction cost→影响rebalancing***

-(cost of selling) < MCVA< (cost of purchase)

MCVA= (alpha of asset) - [2 ×(risk aversion) ×(active risk) × (marginal contribution to active risk of asset)]

[2 × (risk aversion) × (active risk) × MCAR] - *(cost of selling)*

[2 × (risk aversion) × (active risk) × MCAR] + *(cost of purchase)*

alpha of asset

No-trade range for alpha

## Other Issue

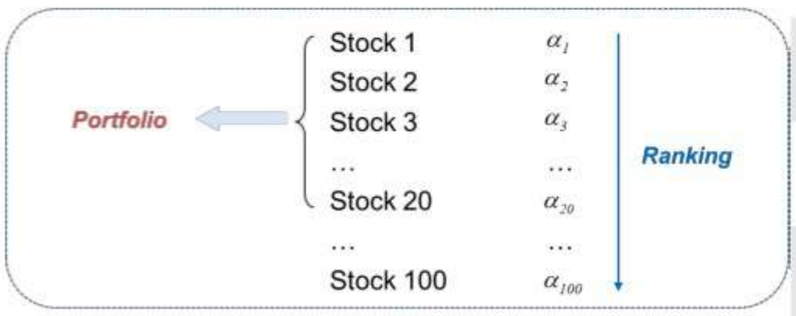
***Proper alpha coverage addressing the case***

- The manager has forecasts of stocks that are not in the benchmark→ ***benchmark weight of zero***
- The manager doesn't have forecasts for assets in the benchmark→ Alphas can be ***inferred***

筛选股票方法

## Method 1: Screens

- Rank the stocks by alpha
- Choose the top performers
- Form either an equally-weighted portfolio or a capitalization-weighted portfolio of stocks




| Strengths | Shortcomings |
|---|---|
| Easy to understand, clear link between cause and effect | Ignore all information |
| Easy to computerize | biases in the alphas |
| Robust, wild estimates alphas do not alter the result | Ignore certain industry with low alpha |
| concentrating in the high-alpha stocks. | fails in addressing risk control purposes |
| limiting the transactions costs by controlling turnover | |

## Method 2: Stratification

- splitting the list of followed stocks into mutually exclusive categories
- Stratification ensures that the portfolio matches the benchmark

| Strengths | Shortcomings |
|---|---|
| • Same benefits as screening<br>• solved the problem of the possible exclusion of some categories of assets | Still suffers from possible errors in measuring alphas. |

## Method 3: Linear Programming

- Uses a type of stratification based on characteristics such as industry, size, volatility, beta, etc. without making the categories mutually exclusive.
- can also include transactions costs

| Strengths | Shortcomings |
|---|---|
| • Create a portfolio that closely resembles the benchmark. | can be different from the benchmark with respect to the number of assets and risk characteristics. |

## Method 4: Quadratic Programming

- Explicitly considers alpha, risk, and transactions costs.
- ultimate approach

# Dispersion

***Dispersion***

- The difference between the maximum return and minimum return for separate account portfolios.
- It is a measure of how an individual client's portfolio may differ from the manager's reported composite returns.

来源

***Sources of Dispersion***

- ***Client-driven***: clients impose different constraints.
- ***Lack of attention*** to separate accounts

***Controlling Forms of Dispersion***

- If ***transactions costs*** were ***zero***, ***Dispersion would disappear***, at no cost to investors.
- With transactions costs, managers should consider transactions costs.

**1.1** The most measurable of the inputs into the portfolio construction process is(are) the:

A. position alphas.

B. transactions costs.

C. current portfolio.

D. active risk aversion.

***C is correct.***

The current portfolio is the only input that is directly observable.

**1.2** Which of the following is correct with respect to adjusting the optimal portfolio for portfolio constraints?

A. No reliable method exists.

B. By refining the alphas and then optimizing, it is possible to include constraints of both the investor and the manager.

C. By refining the alphas and then optimizing, it is possible to include constraints of the investor, but not the manager.

D. By optimizing and then refining the alphas, it is possible to include constraints of both the investor and the manager.

***B is correct.***

The approach of first refining alphas and then optimizing can replace even the most sophisticated portfolio construction process. With this technique both the investor and manager constraints are considered.

**1.3** An- increase in which of the following factors will increase the no-trade region for the alpha ofan asset?

I. Risk aversion.

II. Marginal contribution to active risk.

A. I only.

B. II only.

C. Both I and II.

D. Neither I nor II.

***C is correct.***

This is evident from the definition of the no-trade region for the alpha of the asset.

$$2\times(\text{risk aversion})\times(\text{active risk})\times(\text{marginal contribution to active risk})$$
$$-(\text{cost of selling})\prec\text{alpha of asset}\prec[2\times(\text{risk aversion})\times(\text{active risk})\times$$
$$(\text{marginal contribution to active risk})]+(\text{cost of purchase})$$

**1.4** Which of the following statements most correctly describes a consideration that complicates the incorporation of transactions costs into the portfolio construction process?

A. The transactions costs and the benefits always occur in two distinct time periods.

B. The transactions costs are uncertain while the benefits are relatively certain.

C. There are no complicating factors from the introduction of transactions costs.

D. The transactions costs must be amortized over the horizon of the benefit from the trade.

***D is correct.***

A challenge is to correctly assign the transactions costs to project future benefits. The transactions costs must be amortized over the horizon of the benefit from the trade. The benefits (e.g., the increase in alpha) occurs over time while the transactions costs generally occur at a specific time when the portfolio is adjusted.

**1.5** A manager has forecasts of stocks A, B, and C, but not of stocks D and E. Stocks A, B, and D are in the benchmark portfolio. Stocks C and E are not in the benchmark portfolio. Which of the following are correct concerning specific weights the manager should assign in tracking the benchmark portfolio?

A. Wc = 0.

B. Wc = 0.

C. Wc = (wA + wB)/2.

D. Wc = wD = wE.

***A is correct.***

The manager should assign a tracking portfolio weight equal to zero for stocks for which there is a forecast but that are not in the benchmark. A weight should be assigned to Stock D, and it should be a function of the alphas of the other assets.

**1.6** Which statement about risk control in portfolio construction is correct? (Practice Exam) (Important)

A. Quadratic programming allows for risk control through parameter estimation but generally requires many more inputs estimated from market data than other methods require.

B. The screening technique provides superior risk control by concentrating stocks in

selected sectors based on expected alpha.

C. When using the stratification technique, risk control is implemented by overweighting the categories with lower risks and underweighting the categories with higher risk.

D. When using the linear programming technique, risk is controlled by selecting the portfolio with the lowest level of active risk.

***Answer: A***

Quadratic programming requires many more inputs than other portfolio construction techniques because it entails estimating volatilities and pair-wise correlations between all assets in a portfolio. Quadratic programming is a powerful process, but given the large number of inputs it introduces the potential for noise and poor calibration given the less than perfect nature of most data.

On the other hand, the screening technique strives for risk control by including a sufficient number of stocks that meet the screening parameters and by weighting them to avoid concentrations in any particular stock. However, screening does not necessarily select stocks evenly across sectors and can ignore entire sectors or classes of stocks entirely if they do not pass the screen. Therefore, risk control in a screening process is fragmentary at best.

Stratification separates stocks into categories (for example, economic sectors) and implements risk control by ensuring that the weighting in each sector matches the benchmark weighting. Therefore, it does not allow for overweighting or underweighting specific categories.

Linear programming does not necessarily select the portfolio with the lowest level of active risk. Rather, it attempts to improve on stratification by introducing many more dimensions of risk control and ensuring that the portfolio approximates the benchmark for all these dimensions.

**1.7** An analyst regresses the returns of 100 stocks against the returns of a major market index. The resulting pool of 100 alphas has a residual risk of 18% and an information coefficient of 9%. If the alphas are normally distributed with a mean of 0%, roughly how many stocks have an alpha greater than 4% or less than-4%? (Practice Exam)

A. 5

B. 10

C. 20

D. 25

***Correct answer: a***

**Explanation:** The standard deviation (std) of the alphas = Residual Risk (volatility) x Information Coefficient (IC) = 0.20 * 0.10 = 0.02. So, 4% is twice the standard deviation of the alphas. The alphas follow normal distribution with mean 0, so about 5% of the alphas are out of the interval [-4%, 4%]. The total number of stocks is 100, so roughly there are 5 alphas that are out of the range.

# 2 Portfolio Risk: Analytical Methods

## 1　Portfolio VAR Measures

### Portfolio Risk: Analytical Methods

#### Portfolio VAR Measures

***Portfolio VAR***

$VAR_p = a \times \sigma_p \times W$

***Individual VAR***

$VAR_i = \alpha \times \sigma_i \times |W_i| = \alpha \times \sigma_i \times |w_i| \times W$

***Effect Of Correlation***

$VAR_P = a_c \times W \times \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_1\rho_{12}\sigma_1\sigma_2}$

$$\Rightarrow \begin{cases} Diversified VAR = \sqrt{VAR_1^2 + VAR_2^2} \\ Undiversified\ VAR = VAR_1 + VAR_2 \end{cases}$$

#### Other Portfolio VAR Measures ★★

***Marginal VAR →Δ=1***

$$MVaR = z_c \times \frac{\partial \sigma_P}{\partial \omega_i} = z_c \times \frac{Cov(R_i, R_P)}{\sigma_P}$$

$$= z_c(\beta_i \times \sigma_P) = z_c(\rho_i \times \sigma_i) = \frac{VaR}{W} \times \beta_i$$

***Incremental VAR →Δ=any $***

Incremental VAR
$= VAR_{p+a} - VAR_p$

***Component VAR →Δ=pi***

$CVAR_i = MVAR_i \times P_i = \beta_i \times w_i \times VAR_p$

$$\text{Percent contribution} = \frac{CVAR_i}{VAR} = \beta_i \times w_i$$

**1.1** A portfolio consists of two positions. The VaR of the two positions are $10 million and $20million. If the returns of the two positions are not correlated. The VaR of the portfolio would be closest to:

A. $5.48million

B. $15.00million

C. $22.36million

D. $25.00million

***Answer: C***

For uncorrelated positions, the answer is the square root of the sum of the spread VaRs:

$VAR_p = \sqrt{(10^2 + 20^2)} = \$22.36 million$

**1.2** A portfolio is composed of two securities and has the following characteristics:

| | |
|---|---|
| Investment in X: | USD 1.8 million |
| Investment in Y: | USD 3.2 million |
| Volatility of X: | 8% |

Volatility of Y: 4%

Correlation between X and Y: 15%

The portfolio diversified VaR at the 95% confidence level is closest to:

A. $14,074

B. $206,500

C. $404,740

D. $340,725

***Answer: D***

$$VaR_p = 1.65 \times \sqrt{(1.8 \times 0.08)^2 + (3.2 \times 0.04)^2 + 2 \times 15\% \times (1.8 \times 0.08) \times (3.2 \times 0.04)} = 0.340754$$

**1.3** A portfolio has USD 2 million invested in Stock A and USD 1 million invested in Stock B. The 95% 1-day VaR for each individual position is USD 40,000. The correlation between the returns of Stock A and Stock B is 0.5. While rebalancing, the portfolio manager decides to sell USD 1 million of Stock A to buy USD 1 million of Stock B. Assuming that returns are normally distributed and that the rebalancing does not affect the volatility of the individual stocks, what effect will this have on the 95% 1-day portfolio VaR? (Practice Exam)

A. There will be no effect.

B. It will increase by USD 20,370

C. It will increase by USD 21,370

D. It will increase by USD 22,370

***Answer: D***

VaR(before) = sqrt($40000^2$+$40000^2$+2 × 0.5 × 40000 × 40000) = USD 69282

VaR(after) = sqrt($20000^2$+$80000^2$+2 × 0.5 × 20000 × 80000) = USD 91652

So the VaR will increase by (91,652 – 69,282) = 22,370

**1.4** A portfolio has USD 3 million invested in Stock A and USD 1.5 million invested in Stock B. The 95% 1-day VaR for each individual position is USD 70,000. The correlation between the returns of Stock A and Stock B is 0.4. While rebalancing, the portfolio manager decides to sell USD 1 million of Stock A to buy USD 1 million of Stock B. Assuming that returns are normally distributed and that the rebalancing does not affect the volatility of the individual stocks, what effect will this have on the 95% 1-day portfolio VaR? (Practice Exam)

A. The portfolio VaR will not change.

B. The portfolio VaR will increase by USD 20,370.

C. The portfolio VaR will increase by USD 24,800.

D. The portfolio VaR will increase by USD 28,281.

***Correct answer: c***

Explanation: The first step is to calculate the VaR of the original portfolio of two stocks, A and B. This can be done by using the following equation:

$$VaR_p = \sqrt{\left(VaR_A^2 + VaR_B^2 + 2 * \rho_{AB} * VaR_A * VaR_B\right)}$$

where ρAB is the correlation coefficient. The portfolio VaR (before the rebalancing) is therefore:

$$VaR_p = \sqrt{\left(70{,}000^2 + 70{,}000^2 + 2 * 0.4 * 70{,}000 * 70{,}000\right)} = USD\ 117{,}132$$

After the rebalance, the market value of the position in Stock A is reduced by one-third, so VaRA is now equal to (2/3)*($70,000) = $46,667. Meanwhile the market value for the position in B has risen by two-third so that VaRB is now (1.67)* ($70,000) = $116,667. Hence we can now calculate the VaR of the new portfolio (after rebalancing) as follows:

$$VaR_p = \sqrt{\left(46{,}667^2 + 116{,}667^2 + 2 * 0.4 * 46{,}667 * 116{,}667\right)} = USD\ 141{,}932$$

Therefore, the VaR will increase by (141,932 – 117,132), or USD 24,800.

**1.5** You are asked to evaluate the VaR of a portfolio of two stocks, A and B. estimated at the 95% confidence level and gather the information in the following table:

| Stock | Current Position (USD) | Individual VaR (USD) | Marginal VaR | Beta |
|---|---|---|---|---|
| A | 2,000,000 | 263,177 | 0.068 | 1.3 |
| B | 3,000,000 | 444,110 | 0.080 | 0.9 |
| Total | 5,000,000 | | | |

What IS the difference between the undiversified VaR and diversified VaR of this portfolio? (Important)

A. USD 314,487

B. USD 331,287

C. USD 353,550

D. USD 376,000

***Answer: B***

## 2 Other Portfolio VAR Measures

**The next two questions are based on the following information.**

A risk manager assumes that the joint distribution of returns is multivariate normal and calculates the following risk measures for a 2-asset portfolio:

| Asset | Position | Individual VaR | Marginal VaR | VaR Contribution |
|---|---|---|---|---|
| 1 | USD 100 | USD 23.3 | 0.176 | USD 17.6 |
| 2 | USD 100 | USD 46.6 | 0.440 | USD 44.0 |
| Portfolio | USD 200 | USD 61.6 | | USD 61.6 |

(Practice Exam)

**2.1** If asset 1 is dropped from the portfolio, what will be the reduction in portfolio VaR?

A. USD 15.0

B. USD 38.3

C. USD 44.0

D. USD 46.6

***Answer: A***

A is correct: The new portfolio VaR is that of asset 2 alone (USD 46.6), which implies a reduction in portfolio VaR of USD 61.6 - USD 46.6 = USD 15.0

**2.2** Let $\beta_i = \rho\sigma_i/\sigma_p$, where ρ denotes the correlation between the return of asset i and the return of the portfolio, $\sigma_i$ is the volatility of the return of asset i and $\sigma_p$ is the volatility of the return of the portfolio. What is $\beta_2$?

A. 0.714

B. 1.429

C. 1.513

D. Cannot determine from information provided.

***Answer: B***

$\text{Marginal VaR}_i = \beta_i \times \text{Portfolio VaR} / \text{Portfolio Value}$

So, $\beta_i = \text{Marginal VaR}_i \times \text{Portfolio Value/Portfolio VaR}$

$\beta_2 = 0.44*200/ 61.6 = 1.429$

**2.3** Consider the following two asset portfolios:

| Asset | Position Value (In Thousands of USD) | Return Standard Deviation (%) | Beta |
|---|---|---|---|
| A | 400 | 3.60 | 0.5 |
| B | 600 | 8.63 | 1.2 |
| Portfolio | 1,000 | 5.92 | 1 |

Calculate the component VaR of asset A and marginal VaR of asset B, respectively, at the 95% confidence level.

A. USD 21,773 and 0.1306

B. USD 21,773 and 0.1169

C. USD 19,477 and 0.1169

D. USD 19,477 and 0.1306

***Answer: C***

$$VaR_P = \alpha \times \text{portfolio standard deviation} \times \text{portfolio value}$$
$$= 1.645 \times 0.0592 \times USD1{,}000{,}000$$
$$= USD\ 97{,}384$$
$$\text{Component } VaR_A = USD97{,}384 \times 0.5 \times \frac{400}{1000} = USD19{,}477$$
$$\text{Marginal } VaR_B = USD97{,}384 \times 1.2/USD1{,}000{,}000 = 0.1169$$



**2.4** A risk analyst is evaluating the risks of a portfolio of stocks. Currently, the portfolio is valued at EUR 200 million and contains EUR 15 million in stock A. The standard deviation of returns of stock A is 16% annually and that of the overall portfolio is 21% annually. The correlation of returns between stock A and the portfolio is 0.37. Assuming the risk analyst uses a 1-year 99% VaR and that returns are normally distributed, how much is the component VaR of stock A? (Practice Exam)

A. EUR 2.066 million

B. EUR 2.326 million

C. EUR 5.582 million

D. EUR 7.327 million

***Answer: A***

$$\beta = \rho\frac{\sigma_i}{\sigma_P} = 0.37 \times \frac{16\%}{21\%} = 0.2819$$
$$\text{Component } VaR = 0.2819 \times 2.326 \times 21\% \times 15 = 2.066m$$

**2.5** A risk manager is evaluating the risk profile for a portfolio of stocks. Currently, the portfolio

is valued at JPY 128 billion and contains JPY 25 billion in stock XYZ. The standard deviation of returns of stock XYZ is 11% annually and that of the overall portfolio is 18% annually. The correlation of returns between stock XYZ and the portfolio is 0.6. Assuming the risk analyst uses a 1-year 95% VaR and that returns are normally distributed, what is the estimated component VaR of stock XYZ? (Practice Exam)

A. JPY 2.714 billion

B. JPY 3.838 billion

C. JPY 4.524 billion

D. JPY 6.397 billion

***Correct answer: a***

**Explanation:** Let $\alpha(95\%)$ represent the 95% confidence factor for the VaR estimate, which is 1.645, and $w_{XYZ}$ represent the value of stock XYZ. Therefore,

$VaR_{XYZ} = w_{XYZ} * \sigma_{XYZ} * \alpha(95\%)$ = JPY 25 million x 0.11 x 1.645 = JPY 4.524 billion Component $VaR_{XYZ} = \rho * VaR_{XYZ}$ = 0.6 x 4.524 = JPY 2.714 billion.

## 3 VAR And Risk Budgeting

# VAR And Risk Budgeting

## Managing Risk With VAR

***Buy side vs. Sell side***

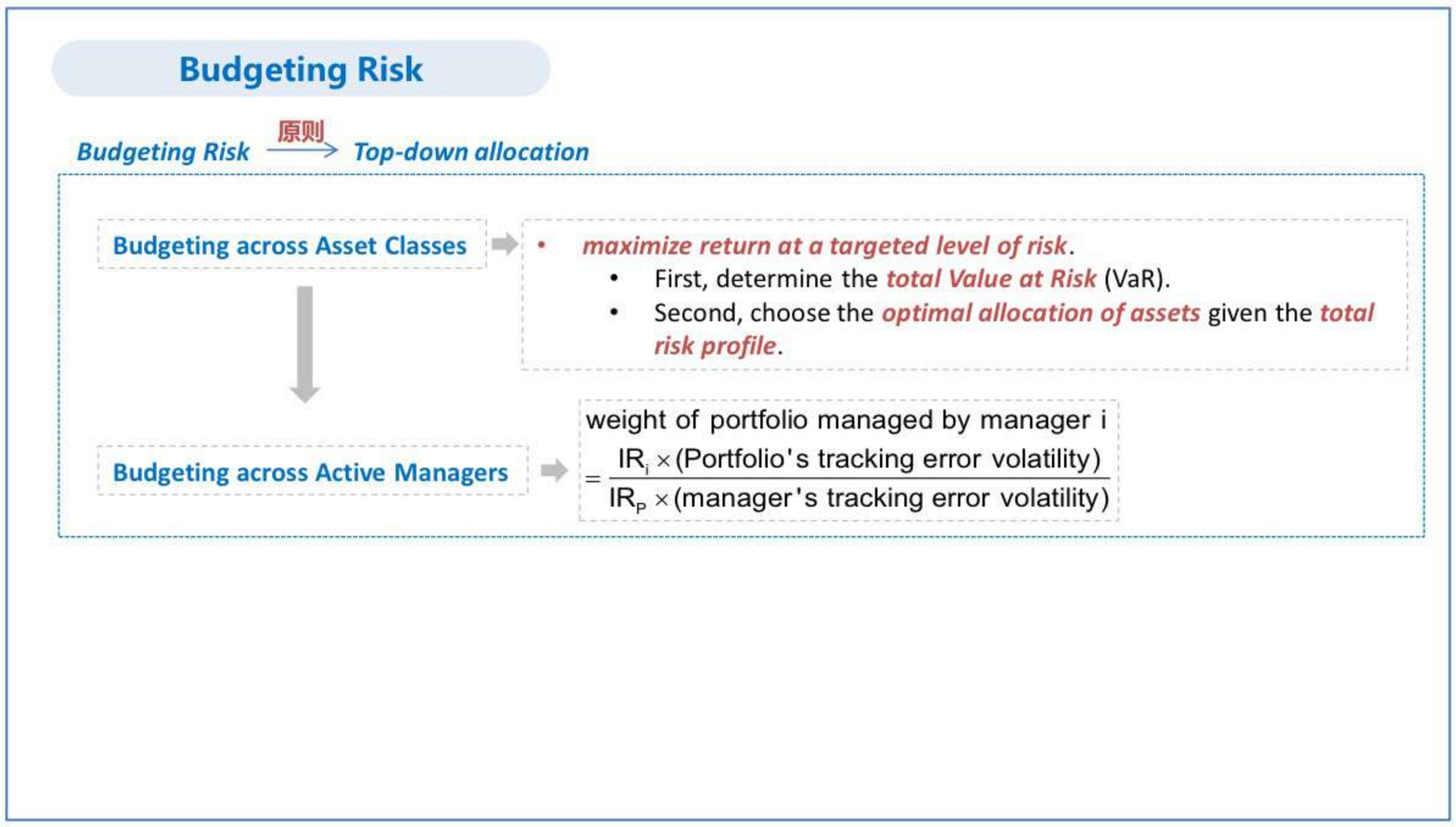
| Characteristic | Sell side | Buy side |
|---|---|---|
| Horizon | Short-term (1 day or less) | Long-term (quarter or longer) |
| Turnover | Rapid | Slow |
| Leverage | High | Low |
| Risk measures | VAR<br>Stress test | Asset allocation<br>Tracking error |
| Risk controls | Position limits<br>VAR limits<br>Stop-loss rules | Diversification<br>Benchmarking<br>Investment guidelines |

- the horizon is ***short***, turnover ***rapid***, and leverage ***high***. ***VAR*** is particularly ***appropriate***.
- ***historical*** measures of risk are ***useless***.
- portfolios are ***highly leveraged***, ***important to control their risk***.

- the horizon is much ***longer***. Positions change more ***slowly***.
- Thus, there is a ***less crucial*** need to control the downside risk.

***VAR is important***

- investments are becoming more ***global*** in nature, creating a need for risk measures that ***take diversification*** into account.
- Second, financial instruments are becoming more ***complex*** over time.
- Third, most investment portfolios are ***dynamic***, with ***changing*** positions




**3.1** The AT&T pension fund has 68%, or about $13 billion invested in equities. Assume a normal distribution and volatility of 15% per annum. The fund measures absolute risk with a 95%, one-year VaR, which gives $3.2 billion. The pension plan wants to allocate this risk to two equity managers, each with the same VaR budget. Given that the correlation between managers is 0.5, the VaR budget for each should be

A. $3.2 billion

B. $2.4 billion

C. $1.9 billion

D. $1.6 billion

***Answer: C***

Call x the risk budget allocation to each manager. This should be such that:

. $x^2 + x^2 + 2\rho xx = \$3.2^2$.

Solving for:

, we find x = $1.85billion. $x\sqrt{1+1+2\rho} = x\sqrt{3} = \$3.2$

Answer A) is incorrect because it refers to the total VaR. Answer B) is incorrect because it assumes a correlation of zero. Answer D) is incorrect because it simply divides the $3.2 billion VaR by 2, which ignores diversification effects.

**3.2** A portfolio manager wants to invest a small amount of new money that has recently come into a fund. The fund is benchmarked to an index and, rather than adding a new holding, the manager is considering increasing the holdings of one of the four assets described in the following table:

| Asset | Expected Return | Beta to the Index | Beta to the Portfolio |
|---|---|---|---|
| A | 12% | 1.2 | 0.90 |
| B | 10% | 0.7 | 0.90 |
| C | 10% | 0.6 | 0.85 |
| D | 8% | 0.3 | 1.10 |

The portfolio manager wants to select the asset that has the lowest marginal VaR as long as its Treynor ratio is at least 0.1. Assuming the risk free rate is 2%, which asset should the portfolio manager select? (Practice Exam)

A. Asset A

B. Asset B

C. Asset C

D. Asset D

***Answer: C***

Explanation:

The Treynor measure is calculated as (Expected Return – Risk Free Rate)/Beta to Index. Assets B, C, D have Treynor measures greater than 0.1. Of these, C has the lowest marginal VaR as its Beta to the portfolio is the lowest.

| Asset | Portfolio Weight | Expected Return | Beta to the Index | Beta to the Portfolio | Correct Treynor | Incorrect Treynor |
|---|---|---|---|---|---|---|
| A | 1.2% | 12% | 1.2 | 0.90 | 0.083 | 0.111 |
| B | 0.8% | 10% | 0.7 | 0.90 | 0.114 | 0.089 |
| C | 0.75 | 10% | 0.6 | 0.85 | 0.133 | 0.094 |
| D | 0.35 | 8% | 0.3 | 1.10 | 0.200 | 0.055 |

**3.3** A pension fund holds the following long positions on a non-dividend-paying biotech stock that is currently trading at USD 90: (Important)

- 70 call options with strike price of USD 70 and one month to expiration.
- 20 call options with strike price of USD 110 and one month to expiration.
- 80 forward contracts with one month to maturity.

Each contract is on one share. If the daily volatility of the stock returns is 1.57% with a mean daily return of 0%, which of the following amounts would be closest to the 1-day 99% VaR of the portfolio, assuming 252 trading days in a year?

A. USD 330

B. USD 385

C. USD 440

D. USD 495

***Answer: D***

**3.4** A risk plan at an investment management organization should be incorporated as a separate section of the organization's strategic planning document. Which of the following statements about the development of a risk plan is correct? (Important)

A. The risk plan should avoid setting explicit goals for expected return and volatility as these are portfolio managers' responsibilities.

B. The risk plan should avoid specifying how much of the organization's risk capital should be directed towards a particular objective.

C. The risk plan should focus on how key dependencies behave in bad environments only as good environments do not pose significant risk.

D. The risk plan should make a distinction between potential loss events that are merely disappointing and those that could threaten the survival of the firm.

***Answer: D***

**3.5** A portfolio manager currently holds 20,000 shares of Costiuk Inc. in a particular portfolio. The daily volume of Costiuk shares traded on the stock exchange is 50,000. Additionally, on any given day, the portfolio manager wishes to trade no more than 15% of the daily trading volume of Costiuk. Which of the following amounts is closest to the liquidity duration of Costiuk in this portfolio?

A. 0.06

B. 0.375

C. 2.67

D. 16.67

***Answer: C***

Liquidity duration is an approximation of the number of days necessary to dispose of a portfolio's holdings (of a particular share in this case) without a significant market impact. It is calculated as: $20{,}000 / (0.15 \times 50{,}000) = 2.67$.

## 4 Surplus at Risk

## Managing Portfolios Using VAR

***From Risk Measurement to Risk Management***

- ***Decrease*** portfolio risk by reducing positions with the ***highest marginal VAR***.
- Repeat process until reached a global minimum.

- ***Increase position with highest SR***

$$\frac{\text{Position i return - risk free rate}}{\text{MVaR}_i} = \frac{\text{Position j return - risk free rate}}{\text{MVaR}_j}$$

## Types Of Risk

***Absolute risk*** — Policy-mix risk; Active-management risk

- ***Most*** of the risk is due to the ***policy mix***
- the ***active-management*** VAR is rather ***small***.
- the policy-mix VAR and active-management VAR ***do not add up to the total-asset VAR***.

***Relative risk*** → Funding Risk / ***Sponsor Risk***

- ***Cash-flow risk***: Risk of year-to-year fluctuations in ***contributions*** to the fund.
- ***Economic risk***: Risk of variation in total ***economic earnings*** of the plan ***sponsor***.

$$R_{surplus} = R_{asset} - R_{Liabilities}\left(\frac{Liabilities}{Assets}\right)$$

Surplus (S) is the difference between the value of the assets (A) and the liabilities (L). The change in the surplus (∆S) is equal to the change in assets (∆A) minus the change in liabilities (∆L). If we normalize by the assets, the return on the surplus is given by:

$$R_{surplus} = \frac{\Delta Surplus}{Assets} = \frac{\Delta Assets}{Assets} - \left(\frac{\Delta Liabilities}{Liabilities}\right)\left(\frac{Liabilities}{Assets}\right)$$

$$= R_{Asset} - R_{Liabilities}\left(\frac{Liabilities}{Assets}\right)$$

Funding risk should be measured as the potential shortfall in surplus over the horizon, this is sometimes called surplus at risk.

**4.1** On January 1, 2006, a pension fund has assets of EUR 100 billion and is fully invested in the equity market. It has EUR 85 billion in liabilities. During 2006, the equity market declined by 15% and yields increases by 1.2%. If the modified duration of the liabilities is 12.5, what is the pension fund's surplus on December 31, 2006?

A. EUR 15.00 billion

B. EUR 12.93 billion

C. EUR 12.75 billion

D. EUR 12.57 billion

***Answer: C***

The surplus at the beginning of the year was 100 – 85 = 15 billion EUR. During the year, the equity portfolio declines 15%, or 15 billion EUR, to 85 billion EUR. Due to the increase in yields, the dollar value of the liabilities decrease by 12.5 × 1.2% × 85 billion EUR, or 12.75. Thus at the end of the year, the assets are worth (100-15)=85billion EUR and the liabilities (85 - 12.75) = 72.25 billion. The surplus is the 12.75, a decrease of 2.25 billion EUR.

**4.2** At the end of 2007, Chad & Co.'s pension had USD 350 million worth of assets that were fully invested in equities and USD 180 million in fixed-income liabilities with a modified duration of 14. In 2008, the wide spread effects of the subprime crisis hit the pension fund, causing its investment in equities to loss 50% of their market value. In addition, the immediate response from the government – cutting interest rates – to salvage the situation, caused bond yields to decline by 2%. What was the change in the pension fund's surplus in 2008? (Practice Exam)

A. USD -55.4 million

B. USD -124.6 million

C. USD -225.4 million

D. USD -230.4 million

***Answer: C***

The change in the pension fund's surplus for the year 2008 is equal to the initial surplus $S_0$ at the end of 2007 less the ending surplus $S_1$ at the end of 2008.

The initial surplus is calculated as $S_0 = 350 – 180 = 170$.

Next we have to calculate the surplus at the end of 2008. Given the 50% decline in the equity market, the new level of assets $A_1$ at the end of 2008 is equal to:

$(1 – 0.5) \times 350 = 175$

The new level of liabilities $L_1$ can be calculated as:

$L1 = (1 – 14 \times (-0.02)) \times 180 = 230.4$

Therefore the 2008 surplus $S_1$ is equal to $A_1 – L_1 = 175 – 230.4 = -55.4$ (which implies the pension fund is actually in a deficit situation at the end of 2008). The change in surplus for 2008 is hence $S_1 – S_0 = -55.4 – 170 = -225.4$ million.

**4.3** SkyLine Airways has a defined benefit pension scheme with assets of $165 million and liability of $150 million. The annual growth of the liabilities is expected to be 4.5% with 2.4% volatility. The annual return on the pension assets has an expected value of 7.8% with 12% volatility. The correlation between asset return and liability growth is 0.35. What is the 95% surplus at risk for SkyLine?

A. $24.97million

B. $54.81million

C. $18.84million

D. $6.12million

***Answer: A***

Expected surplus growth = ($165m × 0.078) - ($150m × 0.045)

Expected surplus growth = $12.87m - $6.75m = $6.12m

Variance of surplus = 355.104， Standard Deviation = 18.84m

Surplus at risk = expected growth in surplus – 1.65 × Standard Deviation of Surplus

Surplus at risk = $6.12m - $31.086m = -$24.97m

Note: Although it is a negative, it is usually expressed as a positive figure as it is assumed that it is a shortfall.

**4.4** An analyst reports the following fund information to the advisor of a pension fund that currently invests in government and corporate bonds and carries a surplus of USD 10 million

| | Pension Assets | Pension Liabilities |
|---|---|---|
| Amount (in USD million) | 100 | 90 |
| Expected Annual Growth | 6% | 7% |
| Modified Duration | 12 | 10 |
| Annual Volatility of Growth | 10% | 5% |

To evaluate the sufficiency of the fund's surplus, the advisor estimates the possible surplus values at the end of one year. The advisor assumes that annual returns on assets and the annual growth of the liabilities are jointly normally distributed and their correlation coefficient is 0.8. The advisor can report that, with a confidence level of 95%, the surplus value will be greater than or equal to: (Practice Exam)

A. USD -11.4 million

B. USD -8.3 million

C. USD -1.7 million

D. USD 0 million

***Answer: C***

The lower bound of the 95% confidence interval is equal to: Expected Surplus – (95% confidence factor × Volatility of Surplus). The required variables can be calculated as follows:

Variance of the surplus = $100^2 \times 10\%^2 + 90^2 \times 5\%^2 - 2 \times 100 \times 90 \times 10\% \times 5\% \times 0.8 = 48.25$

Volatility of the surplus = 6.94

The expected surplus = 9.7

Therefore, the lower bound of the 95% confidence interval = $9.7 - 1.645 \times 6.94 = -1.725$

**4.5** Which of the following statements about risk management in the pension fund industry is correct? (Practice Exam)

A. A pension plan's total VaR is equal to the sum of its policy-mix VaR and active-management VaR.

B. Pension fund risk analysis does not consider performance relative to a benchmark.

C. In most defined-benefit pension plans, if liabilities exceed assets, the shortfall does not create a risk for the plan sponsor.

D. From the plan sponsor's perspective, nominal pension obligations are similar to a short position in a long term bond.

*Correctanswer:d*

**Explanation:** Nominal pension obligations are similar to a short position in a bond.

**4.6** A company's pension fund is established as a defined benefit plan, and therefore the board must consider funding risk. Which of the following statements about the pension fund's funding risk iscorrect? (Practice Exam)

A. The longer the horizon for expected payouts, the lower the funding risk.

B. Decreases in interest rates will reduce funding risk.

C. The funding risk has been effectively transferred to the employees.

D. Funding risk represents the true long-term risk to the plan sponsor.

*Correct answer: d*

**Explanation:** The time horizon of payouts does not eliminate funding risk. In fact it is the mismatch between assets and liabilities that creates funding risk. In an low interest rate environment the value of equities will rise, however the value of the liabilities are likely to increase more thereby exacerbating funding risk. Funding risk is transferred to employees with a defined contribution plan. Immunizing the portfolio, essentially matching duration of assets and liabilities, will reduce funding risk.

**4.7** A risk manager wishes to fully hedge a GBP 100 million equity portfolio with a standard deviation of returns of 30% per year by using Asset A with a standard deviation of returns of 20% per year. The returns of the equity portfolio and Asset A are jointly normally distributed and have a correlation of 0.6. How much of Asset A will have to be sold short to accomplish this hedge? (Important)

A. GBP 18 million

B. GBP 33 million

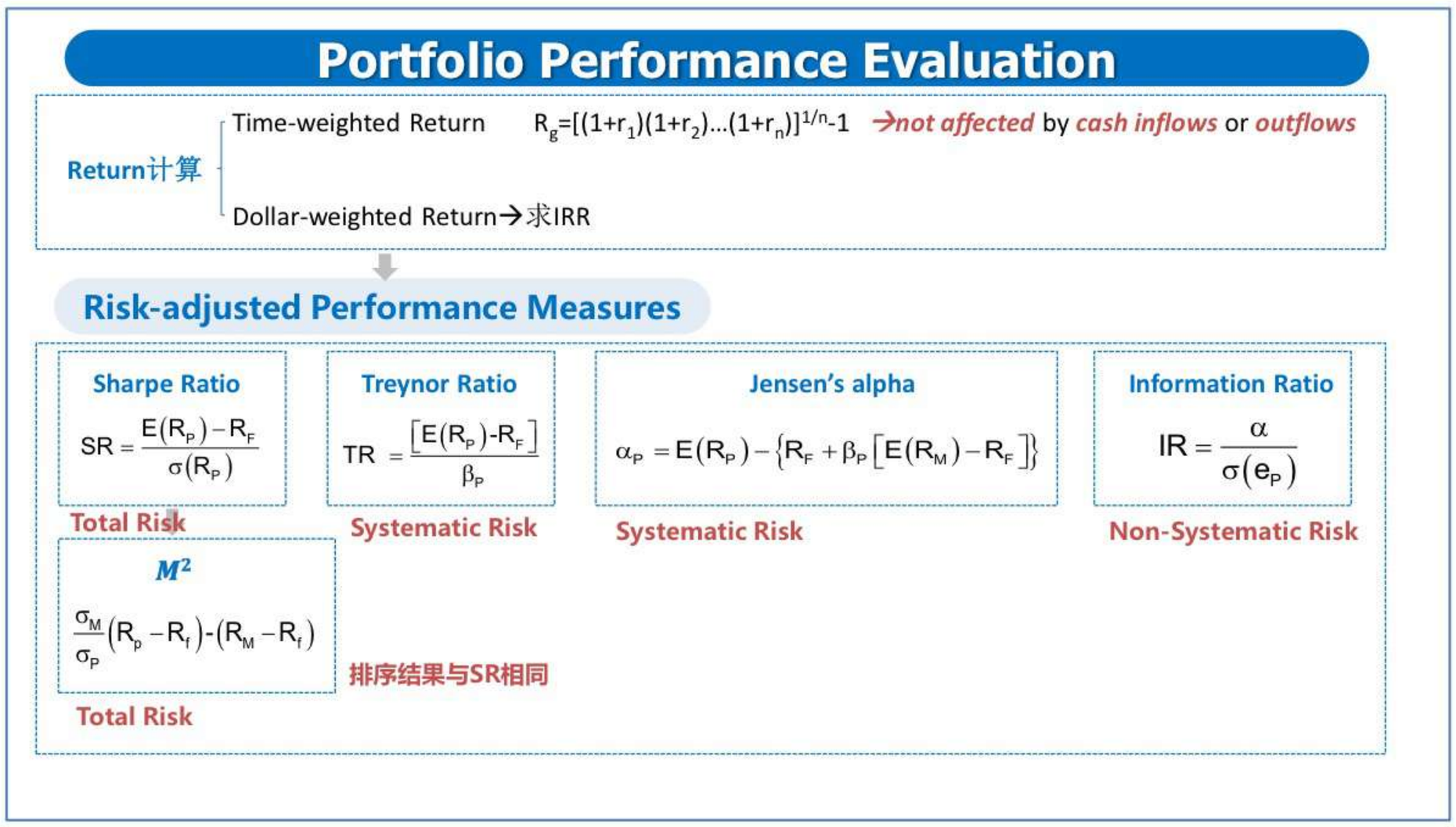
C. GBP 90 million

D. GBP 150 million

*Answer: C*

## 3 Portfolio Performance Evaluation

# 1　Risk-adjusted Performance Measures




**1.1** You make an investment over two periods, from today (T0) to the end of the first year (T1), and then to the end of the second year (T2).

Today (T0), you buy one share at a cost of $10.00. The stock pays a $2.00 annual dividend. At the end of the first year (T1), your single share pays a $2.00 dividend; and, as the price increased by only $1.00, you buy a second share at a cost of $11.00.

By the end of the second year (T2), the stock price has soared to $18.00. You then decide to collect both dividends ($2.00 for each share) and sell both shares, for total proceeds at the end of the second year (T2) of $40.00.

What are, respectively, the time-weighted (aka, geometric) and dollar-weighted (aka, internal) rates of return?

A. 36.5% (time) and 45.8% (dollar)

B. 49.7% (time) and 56.3% (dollar)

C. 53.7% (time) and 60.0% (dollar)

D. 60.2% (time) and 71.2% (dollar)

***Correct answer is C.***

7% (TWR) and 60.0% (dollar-weighted).

Time-weighted (geometric) return:

- R(1) = (11+2-10)/10 = 30%;
- R(2) = (18+2-11)/11 = 81.818%;

- $R(G) = (1.3 \times 1.81818\%)^{(1/2)} - 1 = 53.74\%$

Dollar-weighted return:

$10 + 11/(1+r) = 2/(1+r) + 40/(1+r)^2$;

$10(1+r)^2 + 9(1+r) - 40 = 0$; let $a = (1+r)$:

$10a^2 + 9a - 40 = 0$;

$(5a - 8)(2a + 5) = 0$, such that

$5a = 8$, $a = 1.6$ and $r = 60\%$.

**1.2** You are evaluating the performance of Valance, an equity fund designed to mimic the performance of the Russell 2000 Index. Based upon the information provided below, what is the best estimate of the tracking error of Valance relative to the Russell 2000 Index?

- Annual volatility of Valance: 35%
- Annual volatility of the Russell 2000 Index: 40%
- Correlation between Valance and the Russell 2000 Index: 0.90

A. 3.1%

B. 17.5%

C. 39.6%

D. 53.2%

***Answer: B***

$$\omega^2 = \sigma(p-B)^2 = \sigma(p)^2 + \sigma(B)^2 - 2\times\sigma(p)\times\sigma(B)\times\rho$$
$$= 0.35^2 + 0.4^2 - 2\times 0.35\times 0.4\times 0.9 = 0.0305$$
$$\omega = 17.5\%$$

**1.3** Rick Masler is considering the performance of the managers of two funds, the HCM Fund and the GRT Fund. He uses a linear regression of each manager's excess returns ($r_i$) against the excess returns of a peer group ($r_B$):

$r_i = a_i + b_i * r_B + e_i$

The information he compiles is as follows:

| Fund | Initial Equity | Borrowed Funds | Total Investment Pool | $a_i$ | $b_i$ |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| HCM | USD 100 | USD 0 | USD 100 | 0.0150 | 0.9500 |
| | | | | (t = 4.40) | (t = 12.1) |
| GRT | USD 500 | USD 3,000 | USD 3,500 | 0.0025 | 3.4500 |
| | | | | (t = 0.002) | (t = 10.20) |

Based on this information, which of the following statements is correct?

A. The regression suggests that both managers have greater skill than the peer group.

B. The ai term measures the extent to which the manager employs greater or lesser amounts of leverage than do his/her peers.

C. If the GRT Fund were to lose 10% in the next period, the return on equity (ROE) would be -60%.

D. The sensitivity of the GRT fund to the benchmark return is much higher than that of the HCM fund.

***Answer: D***

Statement d is correct as can be seen from the b coefficient. It. is higher for GRT and lower for HCM. This indicates that the sensitivity of the GRT fund to the benchmark return is much higher than that of the HCM fund.

**1.4** A fund manager recently received a report on the performance of his portfolio over the last year. According to the report, the portfolio return is 9.3%, with a standard deviation of 13.5%, and beta of 0.83. The risk-free rate is 3.2%, the semi-standard deviation of portfolio is 8.4%, and the tracking error of the portfolio to the benchmark index is 2.8%. What is the difference between the value of the fund's sortino ratio (computed relative to the risk-free rate) and its Sharpe ratio?

A. 1.727

B. 0.274

C. -0.378

D. 0.653

***Answer: B***

Sharp ratio = (9.3% - 3.2%)/13.5% = 0.4519, Sortino ratio = (9.3% - 3.2%)/8.4% = 0.7262, so Sortino ratio - sharp ratio = 0.274

**1.5** A portfolio has an average return over the last year of 13.2%. Its benchmark has provided an average return over the same period of 12.3%. The portfolio's standard deviation is 15.3%, its beta is 1.15, its tracking error volatility is 6.5% and its semi-standard deviation is 9.4%. Lastly, the risk-free rate is 4.5%. Calculate the portfolio's information Ratio (IR).

A. 0.569

B. 0.076

C. 0.138

D. 0.096

***Answer: C***

**1.6** Market portfolio's sharp ratio is 40%, the correlation between the market portfolio and the stock is 0.7, the stock's sharp ratio is

A. 12%

B. 28%

C. 32%

D. 30%

***Answer: B***

$$E(R_i)-R_f=\beta_i\times[E(R_M)-R_f]$$

$$\frac{E(R_i)-R_f}{\sigma_i}=\frac{\beta_i\times[E(R_M)-R_f]}{\sigma_i}=\frac{\beta_i}{\sigma_i}\sigma_M\times\frac{[E(R_M)-R_f]}{\sigma_M}=\rho_i\times\frac{[E(R_M)-R_f]}{\sigma_M}=0.7\times40\%=28\%$$

**1.7** Portfolio Q has a beta of 0.7 and an expected return of 12.8%. The market risk premium is 5.25%. The risk-free rate is 4.85%. Calculate Jensen's Alpha measure for Portfolio Q.

A. 7.67%

B. 2.70%

C. 5.73%

D. 4.27%

***Answer: D***

Jensen's alpha is defined by:

$$\alpha_P=E(R_P)-R_F-\beta_P\left(E(R_M)-R_F\right)=0.128-0.0485-0.7\times0.0525=4.27\%$$

**1.8** A Portfolio manager plans to add a new position of USD 100,000 to his current portfolio of USD 10 million. The following information is included in his decision process:

| | Portfolio | Asset A | Asset B |
|---|---|---|---|
| Mean return | 20% | 25% | 25% |

| | | | |
|---|---|---|---|
| Correlation with portfolio | 1.00 | 0.95 | 0.40 |
| Volatility | 35% | 25% | 30% |
| Tracking error | 15% | 12% | 14% |

Given a risk-free rate of 5%, which asset should the portfolio manager choose and why? (Important)

A. Asset A. since it has a lower Sharpe ratio.

B. Asset A, since it has a higher correlation.

C. Asset B, since it has a higher beta

D. Asset B, since it has a higher Treynor ratio.

***Answer: D***

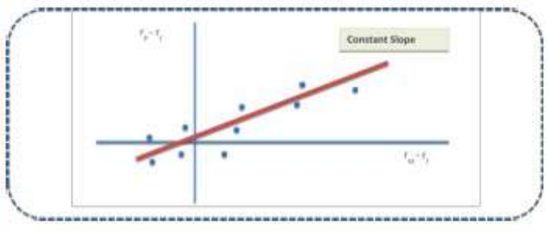
## 2 Other Evaluation Methods

### Other Evaluation Methods

**Market timing**

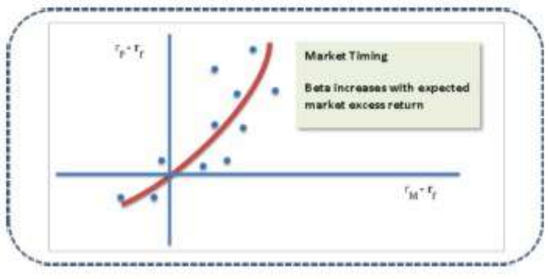
**Case 1: No Market Timing**

$$r_p - r_f = a + b(r_M - r_f)$$




**Case 2: Treynor and Mazuy Model**

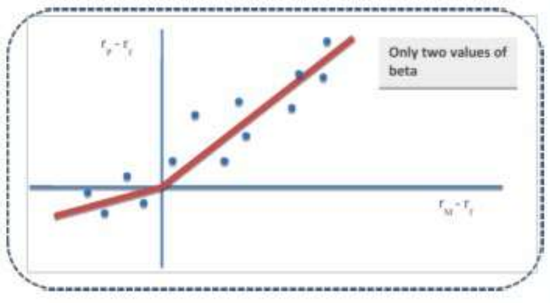
$$r_P - r_f = a + b(r_M - r_f) + c(r_m - r_f)^2 + e_P$$




C>0, good timing

**Case 3: Henriksson and Merton Model**

$$r_P - r_f = a + b(r_M - r_f) + c(r_M - r_f)D + e_P$$




D=1, bull market
C>0, good timing

**Call Option Model**

the returns to the calls + bills portfolio are identical to the 100% perfect foresight returns. Therefore, the value or appropriate ***fee for perfect foresight*** should equal to the ***price of the call option*** on the market index

**Style Analysis**

Style: Value / Growth　　Style: Large / Small

The goal of style analysis is to determine the investment behavior of a fund manager by finding the best asset class exposures in his portfolio.

**Performance Attribution Procedures**

- identify the ***sources of value addition*** to the portfolio.
- attributable to the
  - selection of the right ***asset classes*** (***sectors)***
  - selection of right ***securities*** within an asset class.

**Statistical Significance Of A Performance Measure**

t-test
- ***Null (H0):*** True alpha is zero.
- ***Alternative (Ha):*** True alpha is not zero

$$t = \frac{\alpha - 0}{\sigma / \sqrt{N}}$$ ➡ $\sigma / \sqrt{N}$ ***Standard error of alpha estimate***

**Difficulties In Measuring Hedge Funds Performance**

- ***quickly change*** investment strategy
- ***illiquid assets*** that are difficult to price
- provide profits over a long period of time, but expose the fund to infrequent losses
- Survivorship bias

**2.1** A risk manager runs a performance attribution analysis on an actively managed portfolio using a selected benchmark. The weights and performance of the different market sectors within the portfolio and the benchmark are given below:

| | Benchmark | | Portfolio | |
|---|---|---|---|---|
| Market Sector | Weight | Annual Return | Weight | Annual Return |
| Equity | 20% | 8% | 40% | 6% |
| Fixed Income | 50% | 4% | 55% | 5% |
| Cash | 30% | 2% | 5% | 3% |

What conclusion can be drawn from the data above by using common performance attribution analysis?

A. The portfolio outperforms the benchmark primarily because of the contribution of asset allocation.

B. The portfolio outperforms the benchmark primarily because of the contribution of security selection within market sectors.

C. The portfolio underperforms the benchmark primarily because of the contribution of asset allocation.

D. The portfolio underperforms the benchmark primarily because of the contribution of security selection within market sectors.

***Answer: A***

**2.2** To conduct a Style Analysis on a mutual fund that cannot short securities, you regresses the

fund's returns against five regressors:

T-bills, a small capitalization index, a large capitalization index, a growth index and a value index. The regression returned is: R(t) = 0 ×TBILL - 0.2 ×SMALL + 1.4 ×LARGE + 0.3 ×GROWTH + 0.7 ×VALUE + 1.51. Your colleague Jane criticizes your style analysis with the following statements:

I. You should not have a zero coefficient (0 ×TBILL)

II. You should not have a non-zero intercept (1.51)

III. You should not have a negative coefficient (-0.2 ×SMALL)

IV. You should not have a coefficient that exceeds one (1.4 ×LARGE)

V. The sum of the coefficients should not be different than 1.0 (0 - 0.2 + 1.4 + 0.3 + 0.7 = 2.2 which is not 1.0)

Which of the criticisms is (are) correct?

A. None are correct, the regression is fine

B. II. I. and II. are correct only

C. III. IV. and V. are correct only

D. IV. All are correct.

***Correct answer is C.***

III. IV. and V. are correct only.

The constraints are that the regression coefficients are between 0 and 1.0, and that they sum to 1.0 to represent comparison portfolio that is fully allocated to styles (and no negatives to reflect the prohibition on short positions).

In regard to I., zero is an acceptable coefficient; i.e., the fund is not sensitive to T bills.

In regard to II., the intercept is the return that cannot be attributed to a passive style (asset allocation) and "can be attributed to security selection within asset classes, as well as timing that shows up as periodic changes in allocation" (i.e., alpha; skill or luck).

**2.3** Bodie Kane Marcus define (P) as the measure (score) of market timing ability, where P =P(1) + P(2) - 1, such that P(1) is the proportion of correct forecasts of a bull markets and P(2) is the proportion of correct forecasts of bear markets. Over last ten periods (e.g., quarters), the first five periods saw consecutive bull markets; then the market experienced a secular shift and produced five consecutive bear markets. Money manager Mr. Permabull predicted bull markets for the first eight periods, but then finally resigning to the secular shift, predicted bear markets in the last two periods. What is Mr. Permabull's market timing score?

A. Zero

B. 0.20

C. 0.25

D. 0.40

*D is correct*

P(bull markets) = 5/5 = 100%. P(bear markets) = 2/5 = 40%. P = 100% + 40% - 1 = 0.40.

## 3 Statistical Significance Of A Performance Measure

**3.1** Based on 60 monthly returns, you estimate an actively managed portfolio alpha = 1.24% and standard error of alpha = 0.1278%. The portfolio manager wants to get due credit for producing positive alpha and believes that the probability of observing such a large alpha by chance is only 1%. Calculate the t-statistic, and based on the estimated t-value would you accept (or reject) the claim made by the portfolio manager.

A. t = 9.70, accept

B. t = 2.66, accept

C. t = 2.66, reject

D. t = 9.70, reject

*Answer: A*

$$t = \frac{\text{alpha}}{\text{S.E.}(\text{alpha})}$$

$$t = \frac{1.24\%}{0.1278\%} = 9.702$$

With 60 observations and such a large t value, you would have rejected $H_0$ (alpha = 0). The manager should receive credit for the statistically significant alpha.

**3.2** A manager who obtains an average alpha of 2.5% with a tracking-error of 4%. If he wish the result to be significant to 95%, how many years it is necessary to observe the portfolio return?

A. 8.8 years

B. 9.8 years

C. 10.8 years

D. 11.8 years

*Answer: B*

$$IR \approx \frac{t_{stat}}{\sqrt{T}} \rightarrow T = \left[\frac{t_{stat}}{IR}\right]^2 = \left[\frac{1.96}{2.5\%/4\%}\right]^2 = 9.8 \text{ years}$$

**3.3** Over the past year, the HIR Fund had a return of 7.8%, while its benchmark, the S&P 500 index, had a return of 7.2%. Over this period, the fund's volatility was 11.3%, while the S&P index's volatility was 10.7% and the fund's TEV was 1.25%. Assume a risk-free rate of 3%. What is

the information ratio for the HIR Fund and for how many years must this performance persist to be statistically significant at a 95% confidence level?

A. 0.480 and approximately 16.7 years

B. 0.425 and approximately 21.3 years

C. 3.840 and approximately 0.2 years

D. 1.200 and approximately 1.9 years

***Answer: A***

## 4 Portfolio Choice With Illiquid Assets

### Portfolio Choice With Illiquid Assets

**Characteristics Of Illiquid Markets**

- ***Most asset classes*** are illiquid.
- Markets for illiquid assets are ***large***.
- Illiquid assets comprise the ***bulk*** of most investors' portfolios.
- Liquidity ***dries up*** even in ***liquid*** asset markets.

**Illiquidity arises due to following market imperfections**

- Clientele effects and participation costs
- Transaction costs
- Search frictions
- Asymmetric Information
- Price impact
- Funding constraints

**Three key biases**

| | |
|---|---|
| Survivorship bias | • the tendency of ***poorly*** performing funds to ***stop reporting***.<br>• ***remove*** **survivorship bias is to observe** ***entire population of funds***<br>• In illiquid asset markets we ***never observe the full universe***. |
| Infrequent Sampling | • estimates of risks are ***too low*** when computed using ***reported returns***. |
| Selection Bias | • Sample selection bias results from the tendency of ***returns*** only to be observed when underlying ***asset values are high***.<br>• ***Distressed companies*** are usually not formally liquidated, and these "***zombie***" companies are often left as shell companies. |


## 1 Illiquid Assets

**1.1** Blue Sky Funds, a private equity fund, has suffered low returns for the last five years. As a result, the fund has decided to quit reporting returns. The fund did report returns each year for the last 10 years when performance was strong. This problem of reporting leads to:

A. Survivorship bias.

B. Sample selection bias.

C. Infrequent trading bias.

D. Attrition bias.

*Answer: A*

There are no requirements for certain types of funds, like private equity funds, to report returns. As such, poorly performing funds have a tendency to stop reporting. Additionally, many poorly performing funds ultimately fail. Performance studies generally include only those funds that were successful enough to survive over the entire period of analysis, leaving out the returns of funds that no longer exist. Both of these factors result in reported returns that are too high. This is called survivorship bias.

**1.2** Which of the following variables is not an illiquidity factor that affects equity returns?

A. Measures of adverse selection.

B. The number of recorded positive returns.

C. Turnover.

D. Volume.

***Answer: B***

There are several variables related to illiquidity that are shown to impact equity returns. They are bid-ask spreads, volume, turnover, volume measured by whether the trade was initiated by buyers or sellers, the ratio of absolute returns to dollar volume, the price impact of large trades, informed trading measures (i.e., adverse selection), quote size and depth, the frequency of trades, the number of zero returns, and return autocorrelations. It is not the number of recorded positive returns, but the number of recorded zero returns, that are relevant.

**1.3** Rick Faircloth, a general partner and portfolio manager with Faircloth Funds, is considering ways in which his company can profit from illiquidity risk premiums. He has studied several alternative methods for harvesting illiquidity risk premiums. Which of the following strategies might Faircloth implement that will likely have the greatest effect on portfolio returns?

A. Acting as a market maker for individual securities.

B. Choosing the most illiquid assets within an asset class, even if the asset class is generally considered to be liquid.

C. Allocating a portion of a portfolio to illiquid asset classes.

D. Using dynamic factor strategies at the aggregate portfolio level.

***Answer: D***

**1.4** A significant percentage of hedge funds stop trading each year and drop out of hedge fund databases. Which of the following best describes the impact this has historically had on hedge fund analyses performed using these databases? (Practice Exam)

A. The average performance of hedge funds is overstated.

B. The average volatility of hedge funds is overstated.

C. The average correlation of hedge fund returns is overstated.

D. The average Sharpe ratio of hedge fund returns is understated.

***Correct answer: a***

**Explanation:** As poor performers drop out of the database, the average performance increases.

The removal of poor performers could actually reduce average volatility and the correlation of returns. The Sharpe ratio tends to get inflated due to survivorship bias.

## 5 Hedge Funds

# 1　Hedge Fund Trading Strategy

## Hedge Funds

### Introduction

**Hedge funds vs. mutual funds**

- *Private* versus public
- Ability to take *short positions*
- Freedom to use *high leverage*
- Ability to employ *derivatives*

基金经理技能

**hedge fund manager's skill set**

- An ability to *identify profitable* long as well as short opportunities in a range of asset categories
- The organizational structure to carry *short positions* for extended periods of time
- The know-how to fund *leveraged positions*
- The risk management skill to *maintain complex positions* during volatile markets

历史表现

**Biases In Databases Of Hedge Funds**

- Measurement Bias
- Backfill Bias
- Selection Bias(self-reporting bias)
- Survivorship Bias

行业发展

**Biases In Databases Of Hedge Funds**

- Early Days, 1987-1996
  - Hedge funds *easily outperformed the SNP* index
  - Survivorship and selection biases
- Collapse of Long Term Capital Management in Fall of 1998
  - The collapse of *LTCM* had a dramatic impact on the *private world of hedge fund investors*.
  - There is a *significant reduction in investor*
- Rapid Expansion, 2000-
  - *burst of the dot-com bubble*.
  - *Arrival of Institutional Investors*

机构投资者作用

- Institutional investors are sophisticated.
- risk management, investment process, operational governance improved.
- creation of benchmarking indices

### Hedge Fund Strategies

| Strategy | Details |
|---|---|
| Managed futures | • Managed futures fund managers tend to employ systematic trading programs that largely rely upon *historical price data and market trends*. A significant amount of *leverage* is often employed since the strategy involves the use of *futures contracts*.<br>• CTAs tend not to have a particular bias towards being net long or net short in any particular market |
| Global macro | • typically focus on identifying *miss-pricings* in equity, currency, interest rate and commodity markets.<br>• *top-down* global approach<br>• flexibility to use a *broad investment mandate*.<br>• These approaches may be systematic *trend- following models*, or *discretionary* in nature |
| Risk arbitrage (aka, *Merger Arbitrage*) | • typically attempt to capture the spreads in *merger or acquisition* transactions<br>• Long Target, Short acquirer<br>• The principal risk is usually *deal risk* |
| Fixed Income Arbitrage | • attempt to generate profits by exploiting *inefficiencies* and *price anomalies* between related fixed income securities |

| Strategy | Details |
|---|---|
| Convertible Arbitrage | • *long* positions of *convertible* and *short* the *underlying stock*<br>• creating profit opportunities *irrespective of market moves.* |
| Long/Short Equity | • invest in both long and short sides of equity markets<br>• have the *flexibility to shift investment styles* |
| Dedicated Short Bias | • take *more short positions than long positions*<br>• *focus on companies with weak cash flow* |
| Emerging Markets | • Emerging markets funds typically invest in currencies, debt instruments, equities and other instruments of developing countries' markets (typically measured by GDP per capita). These countries are generally considered to be transitioning toward developed status. |
| Equity Market Neutral strategy | • Their returns can differ dramatically across different months. It appears to us that equity market neutral *does not behave like a single niche strategy*.<br>• Return behavior suggests that different funds apply different trading strategies with a similar goal of achieving almost *zero beta(s)* against a broad set of equity indices. |

**1.1** What critical shift occurred in the hedge fund industry following the collapse of LTCM in 1998 and the dot-com bubble burst in 2001?

A. There was a significant drop in assets under management in the hedge fund industry.

B. There was a large influx of institutional investors investing in hedge funds.

C. Reporting within the hedge fund industry became more regulated than mutual funds.

D. There was a significant increase in hedge fund failures.

*Answer: B*

**1.2** Which of the following statements about convertible arbitrage hedge fund strategies is correct?

A. Credit risk plays only a minor role in convertible arbitrage hedge funds.

B. Investing in convertible arbitrage does not require an understanding of liquidity considerations as the market for convertible securities is sufficiently liquid today.

C. Gamma trading entails significant directional exposure to the equity markets.

D. Re-hedging after a large gain yields trading gains for a typical hedged position in convertible arbitrage hedge funds.

*Answer: D*

Re-hedging after significant moves of the underlying stock price is the essence of gamma trading. Credit risk plays an important role in the risk profile of convertible arbitrage hedge funds. Liquidity considerations are essential. Ignorance of this risk can lead to devastating losses as the 2008 financial crisis showed. Gamma trading means frequent re-hedging of directional exposure after market moves.

**1.3** Identify the risks in a convertible arbitrage strategy that takes long positions in convertible bonds hedged with short positions in Treasuries and the underlying stock.

A. Short implied volatility

B. Long duration

C. Long stock delta

D. Positive gamma

***Answer: D***

This position is hedged against interest rate risk, so B) is wrong. It is also hedged against directional movements in the stock, so C) is wrong. The position is long an option (the option to convert the bond into the stock) and so is long implied volatility, so A) is wrong. Long options positions have positive gamma.

**1.4** George Smith, a hedge fund manager, has just established a short position in short-term Swiss government bonds that are currently yielding 3.5% and a long position in short-term Italian government bonds that are yielding 4.2%. Smith believes the market has underestimated the probability that the Swiss Franc will appreciate relative to the euro. Which of the following hedge fund strategies is most similar to Smith's strategy?

A. Pair trading strategy.

B. Managed futures strategy.

C. Global macro strategy.

D. Event-driven strategy.

***Answer: C***

Global macro strategies take long and short positions based on expectations regarding fundamental changes in global capital markets. The manager in this scenario is engaging in a carry trade by taking a long position in a high-yielding currency (euros) and a short position in a low-yielding currency (Swiss Francs). The manager also expects a fundamental change in the exchange rate between the currencies. Managed futures strategies have a similar philosophy but use futures rather than the underlying assets to execute the strategy.

**1.5** A fund of hedge funds combines a mix of strategy sectors, managers, and styles, and therefore fund of funds risk managers need to understand the common attributes of hedge fund strategies. Which of the following statements is incorrect?

A. Equity market neutral funds aim to generate returns that have low correlation with the overall equity market and to insulate their portfolios from broad market risk factors.

B. Convertible arbitrage funds typically purchase securities that are convertible into the issuer's stock and simultaneously short the underlying stock. These funds earn returns in part form gamma trading on the stock's volatility.

C. Merger arbitrage funds buy the stock of an acquisition target company and simultaneously short the bidding company's stock. These funds have large exposure to deal risk.

D. Equity short-selling funds sell stocks not currently owned by the seller in order to take a directional bet that the stock price will decline. These funds tend to be uncorrelated with traditional long-only equity portfolios.

***Answer: D***

**1.6** An acquisition has been announced by Company A to merge with Target Company T. Before the announcement, Aquirer A's shares traded at $21 and Target T's shares traded at $6 price. The proposed share-for-share exchange ratio was 1:2. Subsequent to the announcement, Aquirer A's shares trade down to $20 and Target T's shares trade up to $8. At this time, a merger arbitrage hedge fund takes a short position in Aquirer's A's stock hedged by a long position in Target T's stock. The merger is successful and the prices close at $28 (Acquirer) and $14 (Target). What is the gain per each single shorted share of Acquirer A?

A. Zero per share of Acquirer A

B. -$2 loss per share of Acquirer A

C. +$1 gain per share of Acquirer A

D. +$4 gain per share of Acquirer A

***Answer: D***

The merger arbitrage is long 2.0 shares of Target T, at $8.00 per share, for each short 1.0 share of Acquirer A, at $20.00 share.

The net gain = 2.0 × ($14 - $8) - 1.0 × ($28 - $20) = $12 - $8 = +$4 per share of Target T.

Any 2:1 price outcome will produce a +$4 per (Target T's) share gain; e.g., $30/15, $32/$16.

**1.7** How would the risk in a merger arbitrage strategy best be characterized?

A. The arbitrage can be structured so there is a gain no matter the outcome.

B. The arbitrageur's loss if the deal does not go through is much greater than the gain if the deal goes through.

C. The arbitrage can be structured as riskless, assuming no other bidders come forward after the initial offer.

D. The arbitrageur's gain on the deal if it does go through is much greater than the loss if the deal does not go through.

***Answer: B***

Typically, the arbitrage is to go long in the target's stock and short the acquirer's stock. The arbitrage is not really a hedge protecting a loss if the deal does not go through. The target stock

could fall below pre-announcement price, and the acquirer stock could substantially increase.

**1.8** The Big Bucks Hedge fund has the following description of its activities. It uses simultaneous long and short positions in equity with a net beta close to zero. Which of the following statements about Big Bucks are correct?

I. It uses a directional strategy.

II. It is a relative value hedge fund.

III. This fund is exposed to idiosyncratic risks.

A. I and II

B. II and III

C. I and III

D. II only

***Answer: B***

**1.9** A risk analyst in a fund of funds is gauging the liquidity risk exposure of a hedge fund by examining the autocorrelation in the fund's returns. If found, a significant first-order autocorrelation coefficient of 0.5 for the monthly historical returns can be seen as an indicator of all of the following except: (Important)

A. High market frictions.

B. Historical return smoothing.

C. Engaging in a managed futures strategy.

D. Investments in the equity of non-public firms.

***Answer: C***

**1.10** Hedge funds may fail for many reasons so picking a fund requires extensive research. As an investor, when performing due diligence on a fund, which of the following findings would be of least concern? (Important)

A. Use of high leverage.

B. Use of multiple prime brokers.

C. High concentration of investments.

D. Exposure to tail events.

***Answer: B***

## 2 Hedge Fund Risk

**2.1** Every year Business Week reports the performance of a group of existing equity mutual funds, selected for their popularity. Taking the average performance of this group of funds will create

A. Survivorship bias only

B. Selection bias only

C. Both survivorship and selection bias

D. Instant-history bias only

***Answer: C***

The publication lists existing funds, so it must be subject to survivorship bias, because dead funds are not considered. In addition, there is selection bias because the publication focuses on just the popular funds, which are large and likely to have done well. Answers a) and b) are incomplete. Answer d) is also incomplete.

**2.2** A factor analysis of returns for hedge funds employing a equity market-neutral strategy produces strongly positive performance information for the strategy (for example, impressive Sharpe ratios). However, the analysis is guilty of neglecting the effects of survivorship bias. If the problem is survivorship bias, which of the following criticisms of the methodology is best?

A. The sample is too small

B. The historical window is too short

C. Risk metrics needs to be included along with return metrics

D. Past performance is no guarantee of future performance

***Answer: A***

The sample is too small: survivorship bias implies that certain non-performing funds (e.g., funds that went out of business) are not included in the sample, it is an issue of the sample.

Answer (D) is closely related and answer (D) is probably true, but (D) relates to interpretation and (A) is more directly the implied methodological flaw. So, (D) is fine, but (A) is a little better.

**2.3** Which of the following statements are true?

I. Hedge fund manager compensation is often symmetric (i.e., a dollar of gain has the opposite impact on compensation as a dollar of loss), while the compensation of mutual fund managers is almost always asymmetric.

II. Leverage obtained through lines of credit increases the risk of a hedge fund more than leverage obtained by issuing debt, because unexpected cancellation of a line of credit by a lender during troubled times can force a fund to liquidate its positions in illiquid markets.

III. A hedge fund investor should pay performance-based compensation to the manager for producing alpha, but should not pay performance-based compensation to a hedge fund manager who has done well because the fund invests in risk factors that mirror the performance of his style or strategy, and the style or strategy has performed well.

IV. The lack of hedge fund transparency is particularly Problematic for investors with fiduciary responsibilities such as pension fund managers, and to secure funding from these investors, hedge fund managers often have to provide more information to these investors.

A. I, II, and IV only.

B. II, III, and IV only.

C. II and IV only.

D. I and III only.

***Answer: B***

Statements II, III, and IV are true. Statement I is false — the opposite is true.

**2.4** For a portfolio of illiquid assets, hedge fund managers often have considerable discretion in portfolio valuation at the end of each month and may have incentives to smooth returns by marking values below actual in high-return months and above actual in low-return months. Which of the following is not a consequence of return smoothing over time?

A. Higher Sharpe ratio

B. Lower volatility

C. Higher serial correlation

D. Higher market beta

***Answer: D***

**2.5** The Peyton Formika Fund is a global macro asset allocation hedge fund designed to provide low correlations with U.S. assets. Dominic James is a fund of hedge funds manager that is analyzing the Peyton Formika Fund for signs of style drift. James makes note of the following findings about the fund:

I. The $R^2$ of the fund versus the global macro peer group has changed from 0.72 to 0.78 over the past 12 months.

II. Due to outstanding returns, assets in the fund have increased from $70 million to $430 million over the past 12 months.

III. The fund made a major shift in allocation by moving 40 percent of its holdings from Eastern European equities to Asian equities.

IV. After a recent trip to India, the fund manager gained confidence in his existing Indian equity holdings and levered his existing 5% weighting in India only by a 10 to 1 ratio.

Which of James' findings are indicators that the Peyton Formika Fund is at risk for style drift?

A. II and IV only

B. I and II only

C. II and III only

D. I, III and IV only

***Answer: A***

Hedge fund style drift occurs when there are changes in the risk factor exposures of the fund or changes in the overall risk of the fund, notably through leverage. Using leverage only for his Indian equity position would definitely be an indicator of style drift. Even though the initial position is small, a 10 to 1 leverage ratio would significantly change the risk of the fund. An excessive cash inflow which may be more money than the manager can sustain is also a potential indicator of style drift. The change in allocation from Eastern European equities to Asian equities is within the objectives of a global allocation fund, so that would not indicate style drift. Also, style drift would be a concern with a decrease, not an increase in the R-squared measure against the peer group.

**2.6** A risk manager is researching the risk profile of a hedge fund by conducting the following regression of the fund's returns on the positive and negative returns of the S&P 500 (Mt):

$R_t = \alpha + \beta^{+}\max(0, M_t) + \beta^{-}\min(0, M_t) + \varepsilon_t$

The results show that $\beta^{+} = 0.2$ and $\beta^{-} = -1.2$ and both coefficients are significantly different from zero. What conclusion can the risk manager draw from the regression results?

A. The returns of the hedge fund exhibit severe asymmetric sensitivity to market movements.

B. The changes in the market returns cause the "phase-locking" behavior of the hedge fund.

C. This hedge fund benefits more from a positive S&P 500 return than it losses from a similar negative S&P 500 return.

D. Survivorship bias strongly affects the return style of this hedge fund.

***Answer: A***

**2.7** The problem of asymmetric risk sharing between investors and fund managers in the hedge 'fund industry can be: (Important)

A. Increased by the existence of a high water mark

B. Increased by high incentive fees for fund managers.

C. Decreased by low fund closure costs.

D. Decreased by limiting the amount that a fund manager can invest in any fund that he

manages.

*Answer: B*

**2.8** QUESTIONS 1 THROUGH 4 REFER TO THE FOLLOWING INFORMATION (Important)

A pension fund invests in a variety of asset classes including bonds, equities, commodities and currencies. To meet growing pension liabilities, the fund's board has been putting a lot of pressure on the chief investment officer (CIO) to increase returns. One proposal that came up at the last board meeting was to invest in hedge funds. The chief risk officer (CIO), in preparing a quarterly report to the board, is concerned about giving an accurate and appropriate representation of the risk the fund faces, responding to several requests from the CIO for information to be included in the report, and investigating the issue of risks related to investing in hedge funds.

1. The CRO has noticed an increase in the fund's 1-month 99% VaR and wants to provide information relevant to determining which asset classes are responsible for the increase. Assuming the correlations of returns between asset classes in the fund are not all zero. Which of the following is the most appropriate measure to use?

A. Calculating the Sharpe radio of each asset class in the fund

B. Computing the beta of each asset class in the fund

C. Calculating the component VaR of each asset class in the fund

D. Computing the marginal VaR of each asset class in the fund

*Answer: D*

2. The pension fund currently has significant credit exposure to Europa and Asia The CRO recommends changing the assumptions in the fund's risk models by increasing the default correlation between bonds issued in Europe and bonds issued in Asia. If the default correlation is increased and all the other parameters are kept the same, which of the following is correct?

A. The fund's expected loss will increase.

B. The fund's unexpected loss will decrease.

C. The fund's expected loss will decrease

D. The fund's unexpected loss will increase

*Answer: D*

3. One of the board members has suggested that the CIO look at several hedge funds that have reported strong performance in recent years. The CRO is familiar with many of these funds and is aware that several invest heavily in illiquid assets and that this may cause standard risk measures based on daily returns to give a misleading picture of their risk. Which of following statements about daily risk measures applied to hedge funds that invest in illiquid assets is correct?

A. Correlation with other investments will be artificially lowered, giving the appearance of

low systematic risk.

B. Infrequent trading reduces the smoothing effects from mark-to-market valuation, giving the appearance of high volatility.

C. Returns of illiquid assets tend to exhibit negative serial correlation, leading to higher long-term volatility.

D. All else being equal, illiquid assets tend to have lower Sharpe ratios, causing the incorrect appearance of an illiquid premium.

***Answer: A***

4. One hedge fund being reviewed recently made a presentation to the fund's investment team which includes the CO. At the presentation, the representative from the hedge fund stated that one of their strategies involves seeking potential fixed income arbitrage opportunities by identifying particular government-guaranteed Ginnie Mae (GNMA) MBS that trade at higher yields than equivalent Treasury securities. Which of the following statements regarding these yields differences is correct?

A. Both securities have no default risk. Therefore, the yield differences represent arbitrage opportunities which the hedge funds can take advantage of by buying GNMA MBS and selling short equivalent Treasury securities.

B. Both securities have no default risk. Therefore, the yield differences represent arbitrage opportunities which the hedge funds can take advantage of by selling short GNMA MBS and buying equivalent Treasury securities.

C. The yield differences do not necessarily represent arbitrage opportunities. The GNMA MBS trade at higher yield than equivalent Treasury securities due mostly to their higher default probabilities.

D. The yield differences do not necessarily represent arbitrage opportunities. The GNMA MBS trade at higher yields than equivalent Treasury securities due mostly to their negative convexities.

***Answer: D***

## 3 Due Diligence