

Risk – an introduction

OBJECTIVES

- Discuss characteristics of returns
- Ratios
- Performance
- The evaluation of strategies

RETURNS

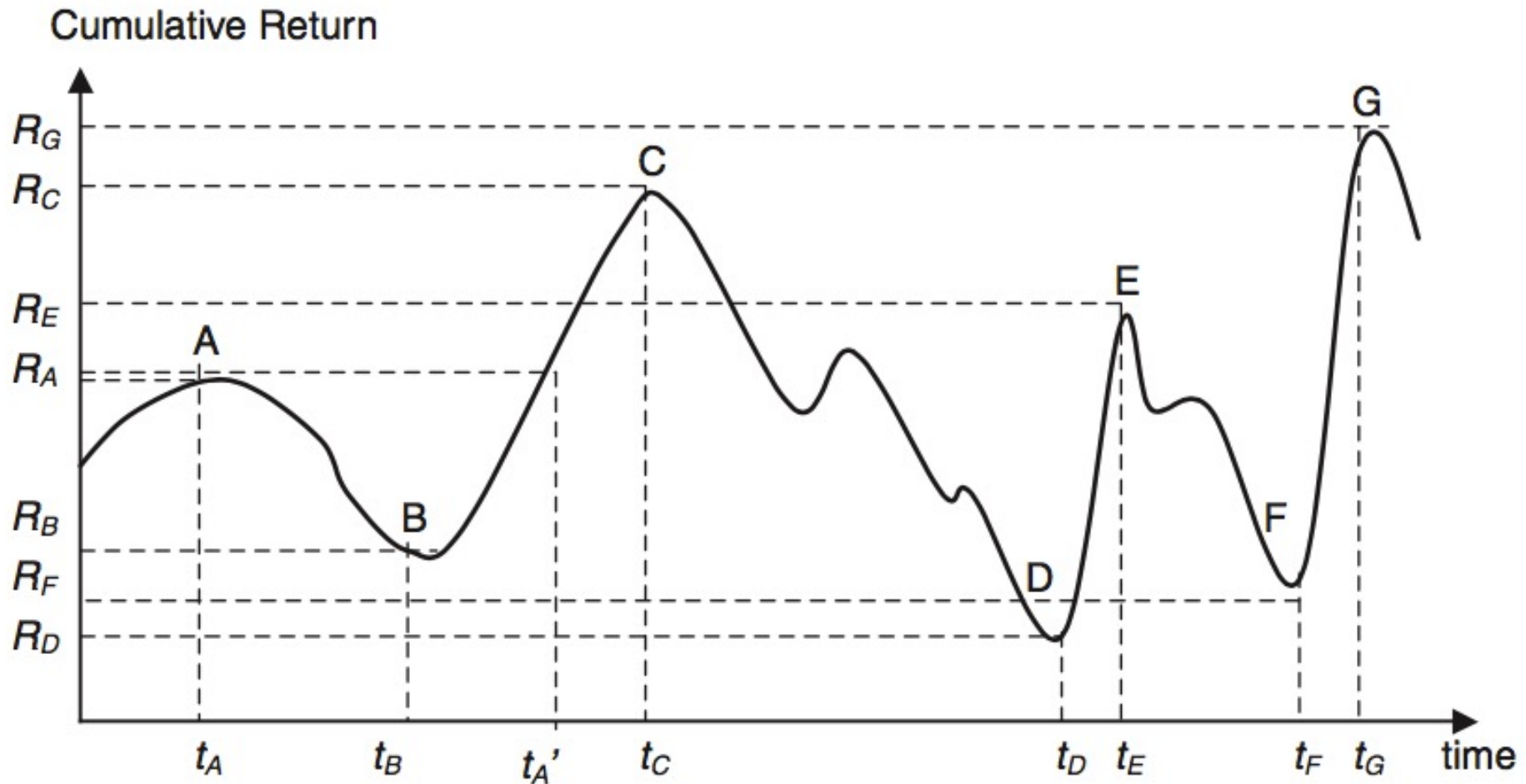
- Return is the most atomic of criteria
 - How much prices change?
- Frequencies may vary
 - Tick by tick, minute, hourly, daily, weekly, etc
- Two moments are of interest
 - Average return over some horizon
 - Volatility of returns
- Maximum drawdown
 - Allows us to model worst case over some horizon

MAXIMUM DRAWDOWN

- Drawdown refers to decline
 - But we need to associate a time dimension
- Maximum drawdown
 - Biggest peak to trough decline
 - Over some time period
- Captures worst case return to a long term investor

- With
$$MDD_T = \frac{(P - L)}{P}$$
 - P peak value before largest drop
 - L lowest value before new high established

MAXIMUM DRAWDOWN



- Key concepts from t_A to t_B
 - High water mark at point A
 - Maximum drawdown at point B

THE CAPITAL ASSET PRICING MODEL

ALPHA

- According to CAPM a portfolio should earn

$$E(r_p) = r_f + \beta_p (E(r_m) - r_f)$$

- IF $r_f = 5\%$, $\beta_p = 1.2$ and $r_m = 11\%$
 - Then portfolio return should be 12.2%
 - $12.2\% = 5\% + 1.2 \times (11\% - 5\%)$
- IF the portfolio returns 13% it performed well
- IF the portfolio returns 11% it performed poorly
- Alpha is the difference between actual and forecast

$$\alpha = r_p - r_f + \beta_p (E(r_m) - r_f)$$

ALPHA

- Positive alpha is good
- Means the stock adds returns
 - Above and beyond market (β) returns
- Sometimes you'll read *alpha generation*
- Source of alpha?
 - Managers stock picking ability
 - Timing
 - *Luck*

ALPHA

- CAPM is used extensively in the industry
 - Used in asset & portfolio evaluation
- Beta is also widely reported
- Be careful !
 - Free is suspect
 - What are assumptions?
- Also CAPM has faults
 - Particularly during periods of economic recession
- Multi-factor models work better

PROBLEMS WITH BETA

- Which market index is to be used?
- Over what time period?
- Is the underlying time series stationary?
 - Structural changes will impact beta
 - How useful can a single point metric be?
- Beta is single factor
 - Ignores others such as size or book value

ALPHA

- Several problems arise using Alpha
- Small firms generally have higher returns
 - But this has reduced since the late 1980s
- Higher book value/market value ratio have higher returns
 - Also reduced since late 1980s
- Momentum trading
 - Past winning stocks tend to outperform past losing
 - This still exists

PERFORMANCE COMPARISON

- Average return, volatility & maximum drawdown
 - Fundamentals but provide simple description
- Sometimes skewness & kurtosis reported
 - Incorporates concept of shape of return distribution
- These metrics are commonly used
 - Fail to provide comparisons of different strategies
- Ideally metrics would incorporate all moments
 - Allow different strategies to be compared

MULTI FACTOR MODELS

MULTI-FACTOR MODELS

- Well documented limitations for CAPM
- The market portfolio is not directly observable
- CAPM is single dimensional
 - Ignores other factors that might drive returns
- OTHERS

ARBITRAGE PRICING THEORY

- APT (Ross, 1976) is based on statistics
 - Not theory like CAPM
- Fundamental concept: not all risk is captured by CAPM
 - The single dimension implied by Beta is faulty
- APT doesn't require mean and variance
 - APT suggests other other factors drive changes
- APT suggests that more then one source of risk exists
 - Therefore a richer model might provide better results

APT

- Arbitrage Pricing Theory (APT)
 - Incorporates multiple risk factors
 - And could include CAPM beta
- Factors can include interest rates, oil prices, etc
- Any factor where a sensitivity can be measured
- An APT model may include as many factors as desired

$$R_i = R_f + b_{1i}F_1 + b_{2i}F_2 + \cdots + b_{Ni}F_N + \varepsilon_i$$

APT

- Consider an APT with three factors
 - F_1 , or CAPM Beta
 - F_2 , or inflation
 - F_3 , or yield spread
- If a firm has the following sensitivities
 - $b_1 = 1.2$
 - $b_2 = -2.2$
 - $b_3 = 0.1$
- Other
 - Risk free rate (r_f) is 3.5%
 - Risk premium is 5%
 - Inflation 2%
 - Yield spread 4%
- What is the risk premium?

APT

- Revisit baseline formula

$$R_i = R_f + b_{1i}F_1 + b_{2i}F_2 + \cdots + b_{Ni}F_N + \varepsilon_i$$

- Gives us

$$R_i = 3.5\% + 1.2(5\%) - 2.2(2\%) + 0.1(4\%) = 5.5\%$$

20 MINUTE BREAK

Value at Risk -- VAR

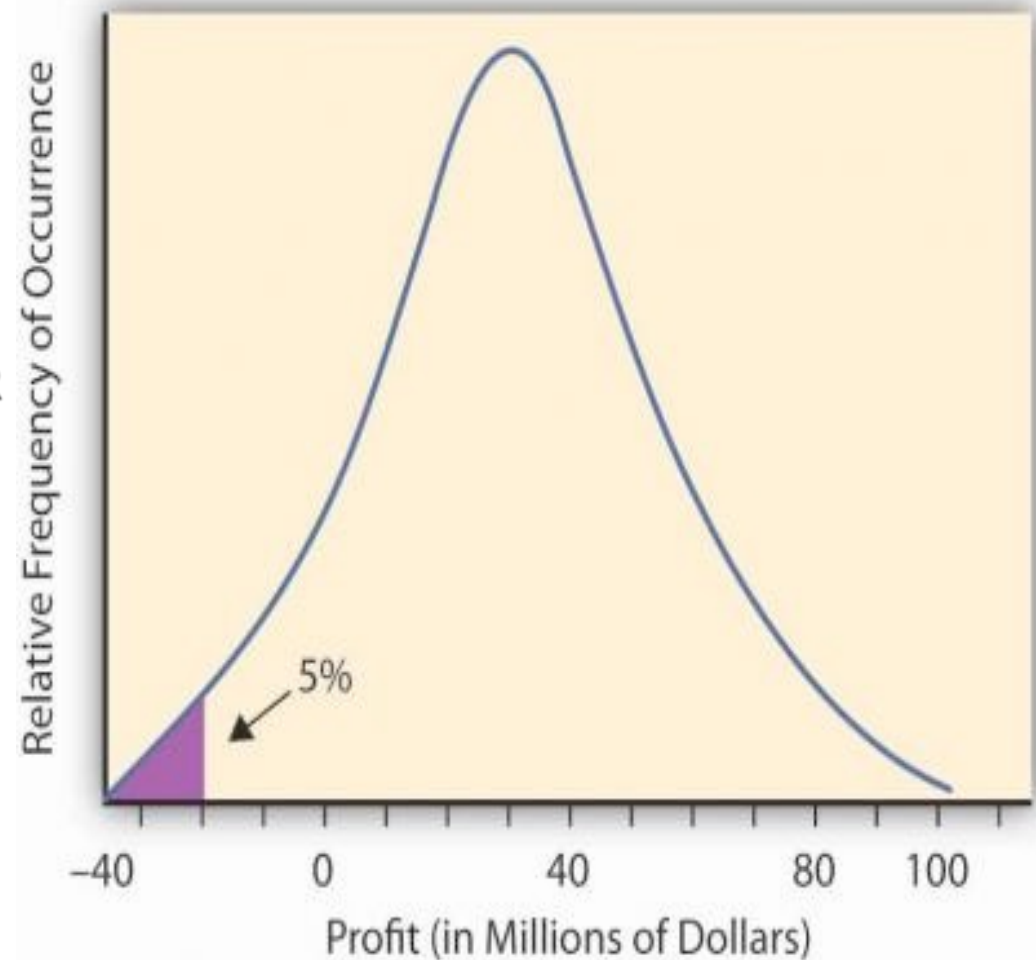
- Widely used by Regulators to set regulatory capital
- Tracked and calculated by trading desks
- VaR asks a very simple question

“What loss level is such that we are $X\%$ confident it will not be exceeded in N business days?”

EXAMPLE OF VALUE AT RISK

Assumptions

- 95% *confidence interval*
- One day *liquidation period*
- VAR is the maximum one day loss, 95% of the time
- Another view - the projected loss - VAR - will only be exceeded 5% of the time
- VAR is the left tail of the *return distribution*
- In this case, VAR is dark blue.



VALUE AT RISK ASSUMPTIONS

- A VaR result is based on specific assumptions
- *Liquidation period t*
- *Confidence interval x*

Without knowing t and x , VaR is meaningless

- Changing either t or x changes the VaR result
- Think about HOW?

VALUE AT RISK ASSUMPTIONS

- The portfolio is assumed to be static over t
- t should reflect *portfolio turnover*
- x must reflect the *risk tolerance* of the portfolio owner
- Many hedge funds have a high degree of risk tolerance
- Institutional investors have low degree of risk tolerance
- Banking - US / European banks differ on risk tolerance
- Most individuals have a low degree of risk tolerance
- *Risk tolerance* is cultural - no “right” or “wrong” answer.

VALUE AT RISK AND REGULATORY CAPITAL

- Regulators base capital requirements of banks on VaR
- Market Risk
 - Required capital is k times the 10-day 99% VaR where k is at least 3.0
- Credit risk & Operational Risk
 - Required capital based on 1Y 99.9% VaR
- Although these are often changed
 - To suit overall market and local conditions

ADVANTAGES OF VAR

- Easy to understand
- Captures an important aspect of risk
 - in a single number
- Single number metric allows for comparison
- Easily communicates present state

VAR ASKS A SIMPLE QUESTION

“What loss level is such that we are $X\%$ confident it will not be exceeded in N business days?”

ASSUMPTION OF NORMALITY

- We assume daily gains/losses are
 - normally distributed independent
 - with mean 0
 - standard deviation σ
- This makes it easy to calculate VaR
 - from the standard deviation (1-day $\text{VaR}=2.33\sigma$)
- The T -day VaR equals $\sqrt{T}$ times
 - one-day VaR

ASSUMPTION OF NORMALITY

- Regulators allow banks to calculate the 10 day VaR as $\sqrt{10}$ times the one-day VaR
- Clearly this is important use of VaR
 - BUT BE CRITICAL
- Do *real* returns follow a *normal* distribution?
 - NO
- Hull (2010) examined USD / JPY returns
 - Returns < 3 SD behaved as expected
 - But ≥ 3 SD the assumption was invalidated

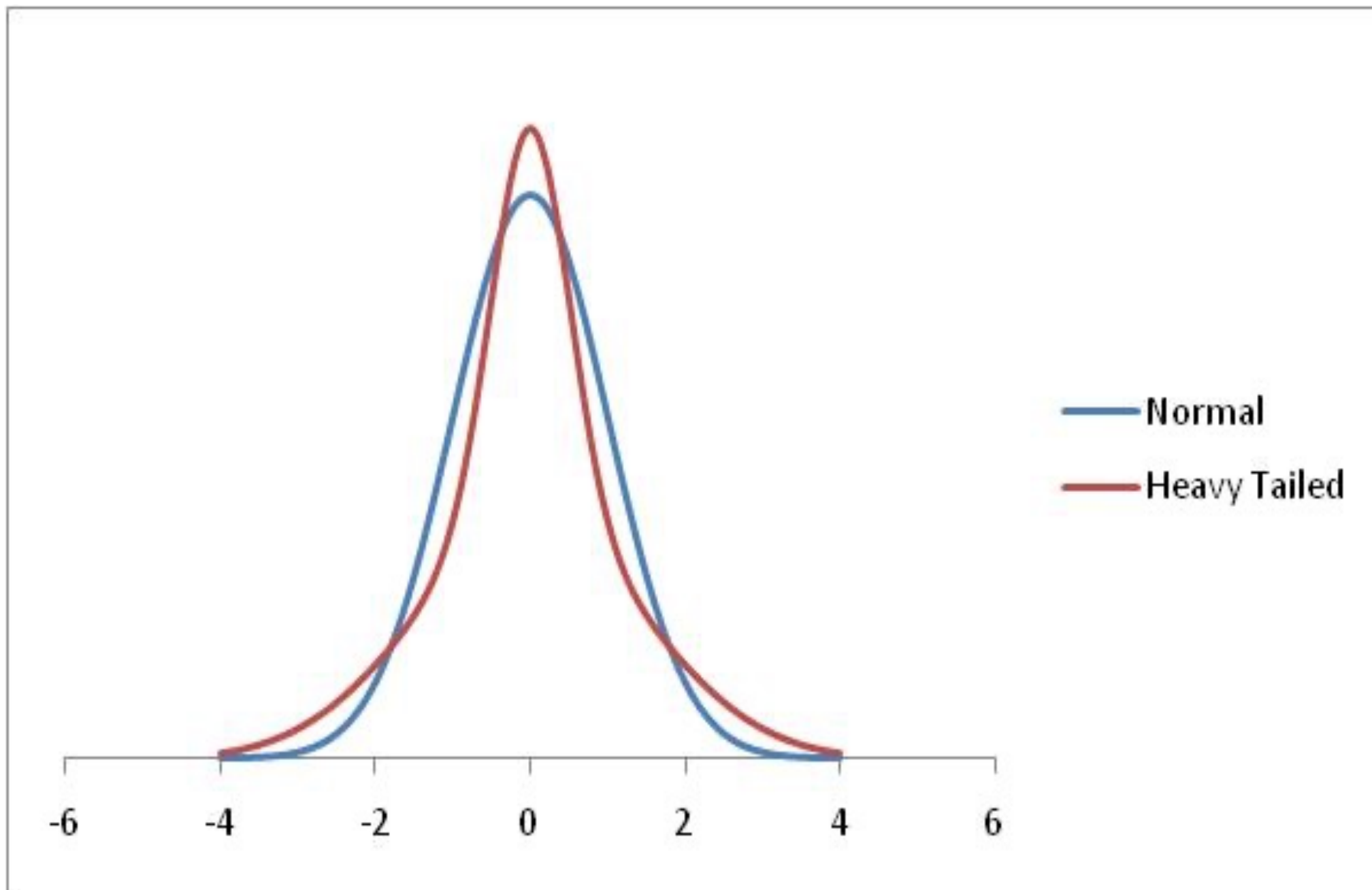
ASSUMPTION OF NORMALITY

	Real World (%)	Normal Model (%)
>1 SD	25.04	31.73
>2SD	5.27	4.55
>3SD	1.34	0.27
>4SD	0.29	0.01
>5SD	0.08	0.00
>6SD	0.03	0.00

HEAVY TAILS & KURTOSIS

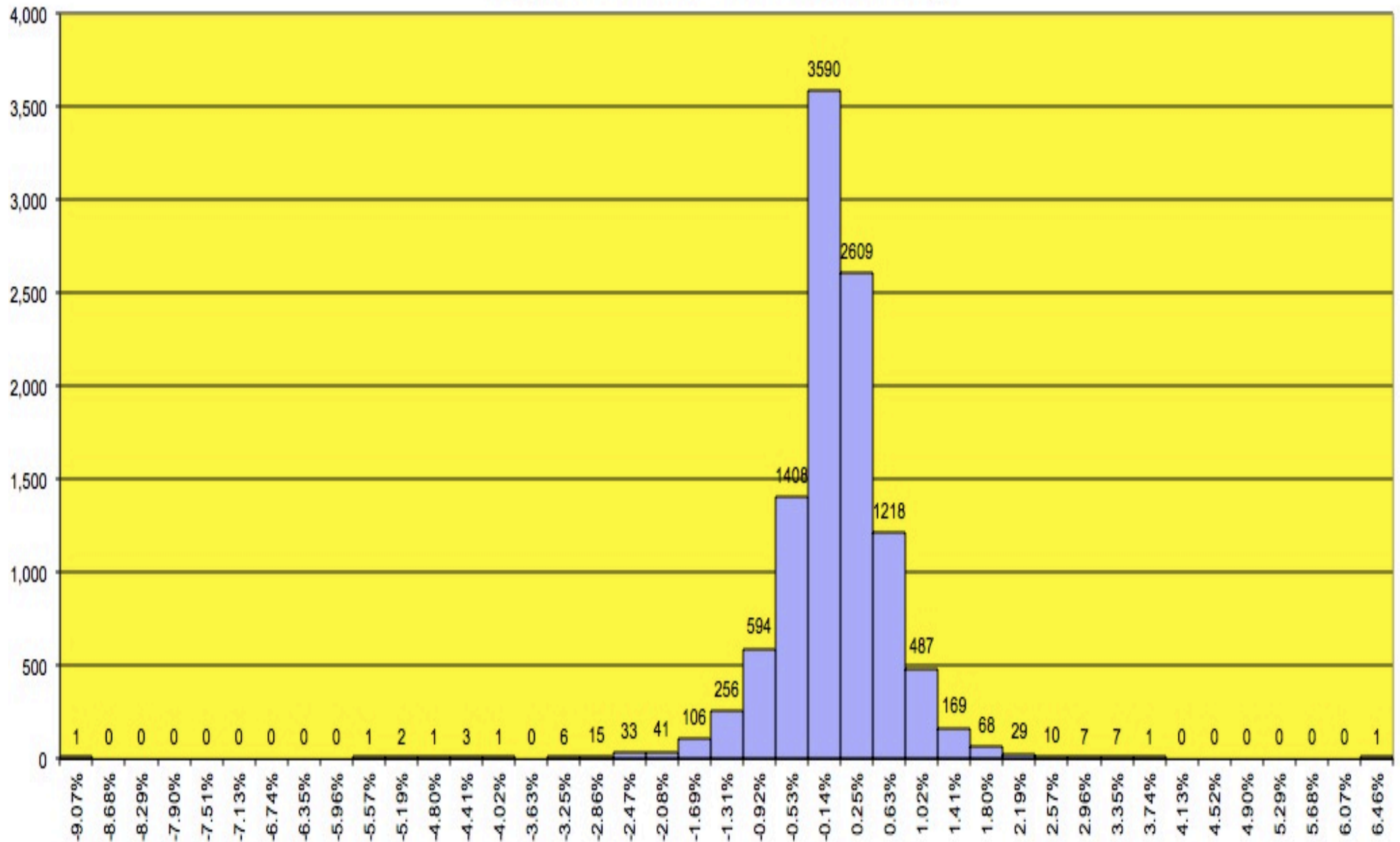
- **Daily USD / JPY not normally distributed**
 - Distribution has heavier tails
 - Implies large changes more likely
- **Observed in many market driven metrics**
- **Known as “excess kurtosis”**

NORMAL & HEAVY TAIL DISTRIBUTION

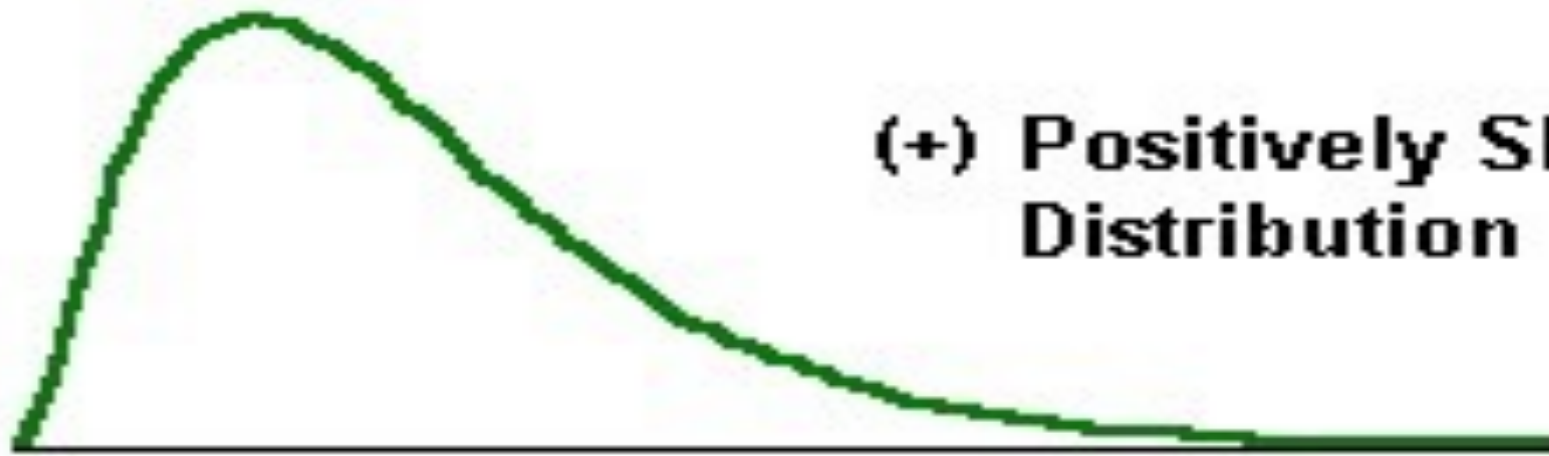


NORMAL & HEAVY TAIL DISTRIBUTION

US \$ / JPY returns - 1971 to 2013 - daily



NORMAL & SKEWED DISTRIBUTION



(+) Positively Skewed Distribution

(-) Negatively Skewed Distribution



CHOICE OF VAR PARAMETERS

- Time horizon
 - how quickly can portfolio be unwound
 - Factors to consider
 - Liquidity of instruments
 - Capability of market to absorb
- Bank regulators use
 - 1-day for market risk
 - 1-year for credit/operational risk
- Fund managers often use one month
- HFT will operate across several minutes
 - But also may consider daily VaR

CHOICE OF VAR PARAMETERS

- Confidence level -- what are objectives?
- Bank regulators use
 - 99% for market risk
 - 99.9% for credit
 - 99.9% operational risk
- Higher confidence intervals imply a “surprise” is less likely
- A bank may want to maintain specific credit rating
 - will often use a confidence levels to this end
- HFT will link this back to preferred drawdown

CALCULATING VAR – THREE APPROACHES

■ Historical simulation

- Apply *previous* observations to current portfolio
- Inapplicable to HFT

■ Monte Carlo Simulation

- Generate *forward looking* scenarios determine portfolio values
- Used in HFT but at daily thresholds

■ Variance-covariance method

- Assuming a distribution (usually *normal*), use statistical properties of the portfolio to find VAR
- Can be used in HFT but calculation intensive

VAR FOR A SINGLE ASSET

$$\text{VaR}_{asset} = \mu - \alpha \sigma_{asset}$$

■ With

- μ the *expected return* of the asset
- σ *standard deviation* of the asset
- α is a *deviate* (from statistics)

■ As a rough calculation apply this to a portfolio

VAR FOR A SINGLE ASSET

- Descriptive stats for a portfolio
 - Over six month horizon
 - μ \$2 million
 - σ \$10 million
- α is 2.33 for 99% confidence
- The 1% point of the VaR distribution
 - is $2 - 2.33 \times 10$ or \$21.3 million
- In other words, VaR for the portfolio
 - with a six month time horizon and 99% confidence level

Risk – an introduction