Corporate Finance I

Event Studies

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Motivation

- What is an event study?
  - Statistical method to analyze stock prices
  - Measure the impact of a specific event on firm value
  - Analyze stock price reactions
  - Separate the systematic impact of events from pure chance
- Why is this important?
  - Stock prices contain important information.
  - … but you have to be able to extract it.
  - Greatest hazard: overinterpretation

BHP Billiton‘s bid for Rio Tinto

An example

- On November 8, 2007, BHP Billiton announced a bid for its competitor Rio Tinto.
- BHP Billiton is no. 1 in mining sector (MCAP).
  - MCAP of about $240bn (AUS and UK combined)
- Rio Tinto is no. 3 in mining sector (MCAP).
  - MCAP is about $130bn (AUS and UK combined)
- The deal would create the fifth largest company worldwide.
- Both companies are dual-listed in the UK and Australia.

BHP Billiton's bid for Rio Tinto

Summary data

	07.11.2007	08.11.2007	09.11.2007
		Rio Tinto (UK)	
Price (Day-End)	£43.50	£52.96	£56.24
Percent change		21.75%	6.19%
MCAP (bil.)	£43.37	£52.81	£56.08
		BHP Billiton (UK)	
Price (Day-End)	£17.56	£16.56	£16.28
Percent change		-5.69%	-1.69%
MCAP (bil.)	£39.31	£37.07	£36.43
		UK FTSE All Share	
Price (Day-End)	3,285.09	3,278.30	3,237.32
Percent change		-0.21%	-1.25%

Note: MCAPs refer to the UK part of the shares only.

For calculations see *Event studies.xls*, tab "Overview".

Overview

- Contents of this lecture:
  - Set-up of an event study
  - Calculating normal and abnormal returns
  - Cumulative abnormal returns
  - Significance tests
  - Potential problems and further issues

Interpreting stock prices

- Interpret a single firm's stock price reaction to an event:
  - First calculate the expected return (if no event occurred)
  - Then calculate the return relative to a benchmark:
    - Difference between actual return and expected return

- Limitations of this approach:
  - What to do if other events take place at the same time?
  - How do we know that the stock price reaction is actually caused by the event?
  - How can we find out whether a specific event is good or bad for firms in general (i.e. for all firms on average)?

Typical event study questions

- What is the effect of positive (negative) earnings announcements?
- Does a hostile takeover increase the value of the acquiring company?
- Do divestitures create value?
- Does a specific amendment of the company's charter increase or decrease the value of this company?
  - Introduction of a poison pill
  - Introduction of an option plan for management compensation
- Does the conversion of non-voting shares into voting shares ("stock unification") increase firm value?

Set-up of an event study (1)

Overview

- Determine the type of event:
  - E.g., announcement of a tender offer
- Determine the selection criteria:
  - E.g., all U.S. firms listed at the NYSE between 1980 and 1989
- Search for all companies that fulfil the selection criteria and that were subject to such an event:
  - Let $j = 1, \ldots, N$ identify the companies in this sample.
- Determine for each firm the precise event date.
  - t denotes the event time (in days).
  - $t = 0$ denotes the event date.

Event days: BHP & RIO

	07.11.2007	08.11.2007	09.11.2007
		Rio Tinto (AUS)	
Price (Day-End)	112.22 AUD	113.40 AUD	130.90 AUD
Percent change		1.05%	15.43%
MCAP (bil.)	51.26 AUD	51.80 AUD	59.80 AUD
		BHP Billiton (AUS)	
Price (Day-End)	44.86 AUD	43.24 AUD	42.47 AUD
Percent change		-3.61%	-1.78%
MCAP (bil.)	150.55 AUD	145.12 AUD	142.53 AUD
		S&P ASX 200	
Price (Day-End)	6,692.40	6,521.60	6,545.70
Percent change		-2.55%	0.37%

Note: MCAPs refer to the Australian part of the shares only.

For calculations see *Event studies.xls*, tab “Overview”.

Set-up of an event study (2)

Event windows

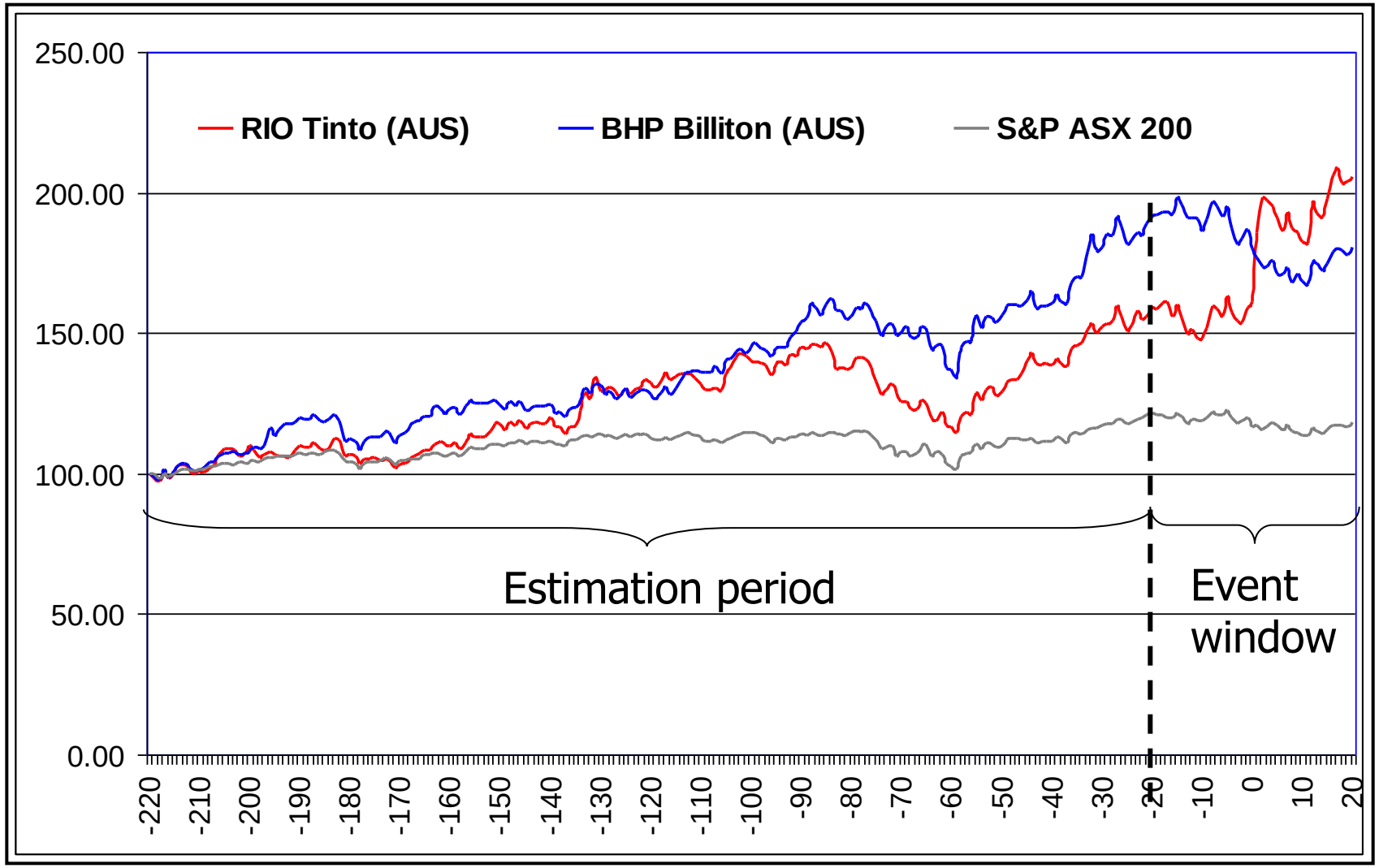
- Determine the event window:
  - We will search for abnormal returns over this window.
  - E.g. t = -20, …, +20; often asymmetric (e.g. -20, …, +10)
- Issues:
  - Need to capture event:
    - When did the information reach the market?
    - If in doubt use longer window
  - When did the market digest the information?
    - Typically instantaneously
  - Mixing with other information:
    - If in doubt use shorter window
  - Was there insider trading (runup)?

Set-up of an event study (3)

Estimation period

- Determine the estimation period:
  - Previous “clean” period used for estimating parameters
  - No event during this period
  - Infer the normal performance of the stock
    - e.g., $t = -220, \ldots, -21$
- Obtain the daily stock returns for all firms for both windows, i.e. for $t = -220, \ldots, +20$:
  - Beware of dividend payouts and stock splits

Relative Price Development (AUS)



For calculations see *Event studies.xls*, tab "Relative Price Development (AUS)".

Normal and abnormal returns

- We need to to calculate the "normal" or expected return, $E(r_{jt})$
  - for each firm *j* and each day *t* in the event window;
  - then we calculate the abnormal returns $AR_{jt} = r_{jt} - E(r_{jt})$,
  - where r_{jt} is the return of firm *j* 's stock on day *t.*
- There are several models for calculating normal returns. We will look at three:
  - Mean-adjusted return model
  - Market-adjusted return model
  - Market model

The mean-adjusted return model

- Calculate the mean of the returns of firm *j* over the estimation period:
  - This is the expected return:

$$E(r_{jt}) = \bar{r}_j = \frac{1}{200} \sum_{t=-220}^{-21} r_{jt}$$

  - Naïve but still frequently used model
  - Advantage: No additional data (market index) needed.
  - RIO: 0.29% → AR=21.75% - 0.29% = 21.45%
  - BHP: 0.36% → AR=- 5.69% - 0.37% = - 6.06%

For calculations see *Event studies.xls*, tabs “Rio Tinto UK” and “BHP UK”. Refer to columns D and E, line 234.

The market-adjusted return model

- Here, the expected return is simply the market return:

$$E(r_{jt}) = r_{Mt}$$

  - r_{Mt} is the return on the market portfolio:
    - Usually proxied by a broad market index like the S&P500
  - Advantage: No estimation period necessary
    - as long as no statistical tests are performed.
  - On Nov 8, 2007 the FTSE fell by 0.21%.
  - Abnormal returns in example:
    - RIO: 21.75% - (-0.21%) = 21.95%
    - BHP: -5.69% - (-0.21%) = - 5.49%

For calculations see *Event studies.xls*, tabs “Rio Tinto UK” and “BHP UK”. Refer to columns H and I, line 234.

The market model

- In the market model, the expected return is given by:

$$E(r_{jt}) = \hat{\alpha}_j + \hat{\beta}_j r_{Mt}, \quad t = -20,...,+20$$

- $\hat{\alpha}_j$ and $\hat{\beta}_j$ are the estimates from the following regression:

$$r_{jt} = \alpha_j + \beta_j r_{Mt} + \varepsilon_{jt}, \quad t = -220,...,-21$$

- Regression across observations from the estimation period

- Possible statistical refinement: use log returns

$$r_t = \ln\left(\frac{P_t + D_t}{P_{t-1}}\right)$$

Market model: Alpha & Beta

Rio Tinto (UK)		BHP Billiton (UK)	
Alpha	0.0025	Alpha	0.0032
Beta	1.6459	Beta	1.8771

Rio Tinto (AUS)		BHP Billiton (AUS)	
Alpha	0.0026	Alpha	0.0018
Beta	-0.0538	Beta	1.5685

- Abnormal returns on November 8, 2007:
- RIO: 21.75% - (0.25% + 1.6459x(-0.21%)) = 21.84%
- BHP: -5.69% - (0.32% + 1.8771x(-0.21%)) = - 5.62%

For calculations see *Event studies.xls*, tabs “Rio Tinto UK” and “BHP UK”. Refer to columns A-C, lines 3 and 4.

Which model should be used?

- The most general model is the market model:

$$E(r_{jt}) = a_j + b_j r_{Mt}$$

  - For $\beta_j = 0$ it is equal to the mean-adjusted model.

$$E(r_{jt}) = a_j = \bar{r}_j$$

  - For $\beta_j = 1$ and $\alpha_j = 0$ it is equal to the market-adjusted model.

$$E(r_{jt}) = r_{Mt}$$

  - For $\alpha_j = (1 - \beta_j)\, r_F$ it is equal to the CAPM (where r_f is the risk-free return)

$$E(r_{jt}) = (1 - b_j) r_F + b_j r_{Mt} = r_F + b_j (r_{Mt} - r_F)$$

- Market model is the most popular method used for calculating expected returns.
  - We will use this method in what follows.
- Typically, the choice of the model has not much influence on the results.

Cumulative abnormal returns

- Calculate abnormal return $AR_{jt} = r_{jt} - E(r_{jt})$

  - Cumulate abnormal returns over the event window
  - This is the cumulative abnormal return:

$$CAR_t = \sum_{\tau=-20}^{t} AR_\tau$$

  - Plotting CAR_t against t shows how the information is incorporated into prices.

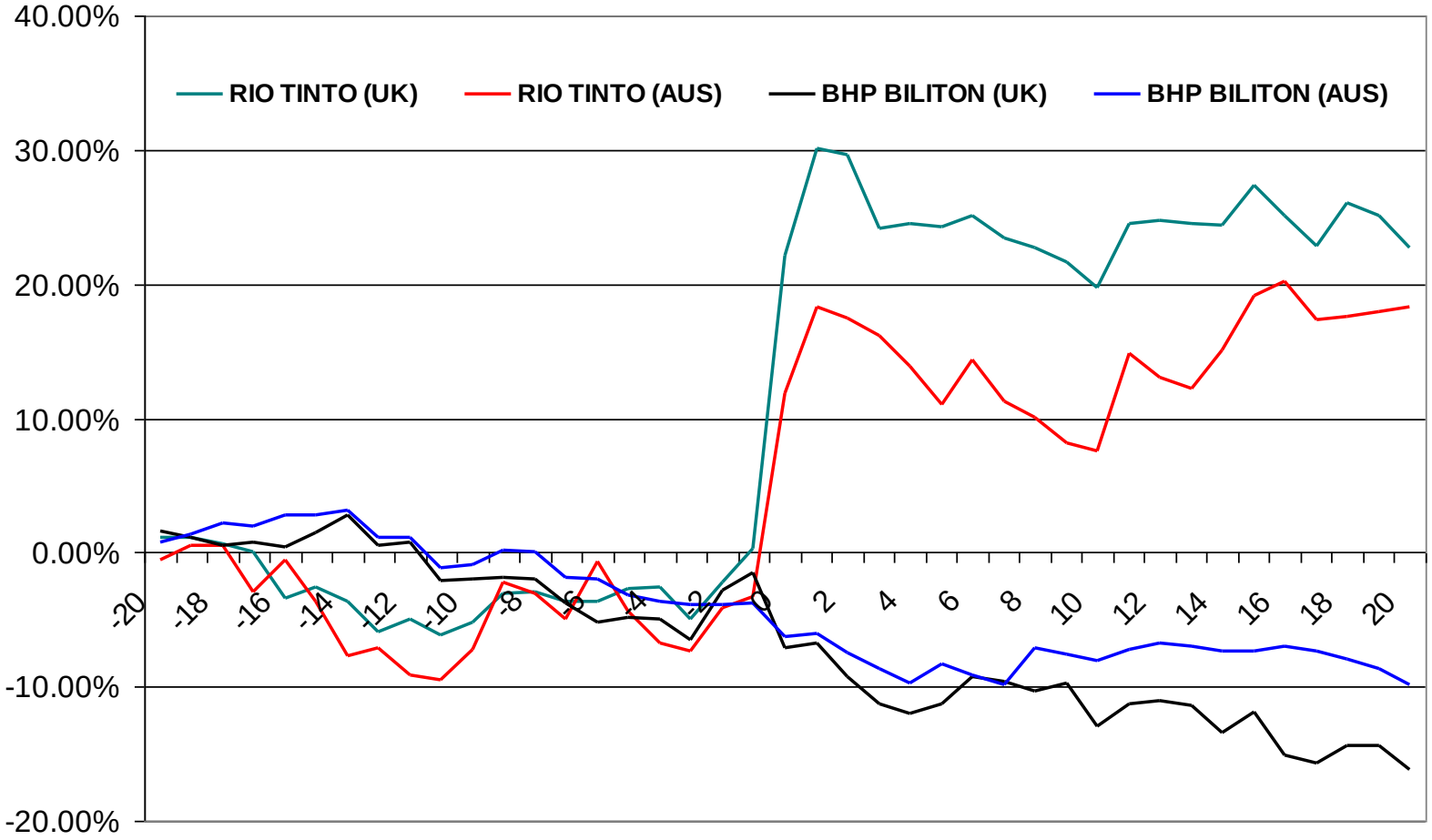
Calculating CARs

Event time t	RIO Tinto (UK) Abnormal Return	RIO Tinto (UK) CAR (-20, t)
-20	1.13%	1.13%
-19	-0.01%	1.12%
-18	-0.45%	0.68%
-17	-0.68%	-0.01%
-16	-3.39%	-3.40%
-15	0.77%	-2.63%

$$CAR(-20,t) = CAR(-20,t-1) + AR(t)$$

For calculations see *Event studies.xls*, tabs “Rio Tinto UK”. Refer to columns B, I, and M, lines 214-219.

CAR (-20,+20)


40.00%
30.00%
20.00%
10.00%
0.00%
-10.00%
-20.00%
RIO TINTO (UK)
RIO TINTO (AUS)
BHP BILITON (UK)
BHP BILITON (AUS)
-20
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
14
16
18
20

Significance tests

- Is the abnormal return at or around the time of the event statistically significant?
- Null hypothesis:
  - The event has no impact on firm value and observed returns are different from zero only by chance.
  - H_0: CAR = 0
- Assumption:
  - Returns r_{jt} are independent and identically normally distributed.
- We will derive the tests for the market model.
  - Slight changes are necessary for the other two models.

Testing for one day and one firm

- Postulate normal distribution for abnormal returns:

$$AR_{jt} \sim N(0, \sigma_j^2)$$

- σ_j^2 can be estimated from the data in the standard way:

$$\hat{\sigma}_j^2 = \frac{1}{198} \sum_{t=-220}^{-21} \hat{\varepsilon}_{jt}^2$$

- Where $\hat{\varepsilon}_{jt}$ are the residuals of the market model regression:

$$r_{jt} = \alpha_j + \beta_j r_{Mt} + \varepsilon_{jt}, \; t = -220, \ldots, -21$$

- In our example:
- RIO: σ = 1.71%
- BHP: σ = 1.45%

For calculations see *Event studies.xls*, tabs “Rio Tinto UK” and “BHP UK”. Refer to columns A-C, line 6.

The t-test for one day and one firm

- Hence, under the null hypothesis:

$$\frac{AR_{jt}}{\hat{\sigma}_j} \sim T(198) \approx \mathrm{N}(0,1)$$

- This statistic tests whether the abnormal return on the day of the announcement is significantly different from zero.

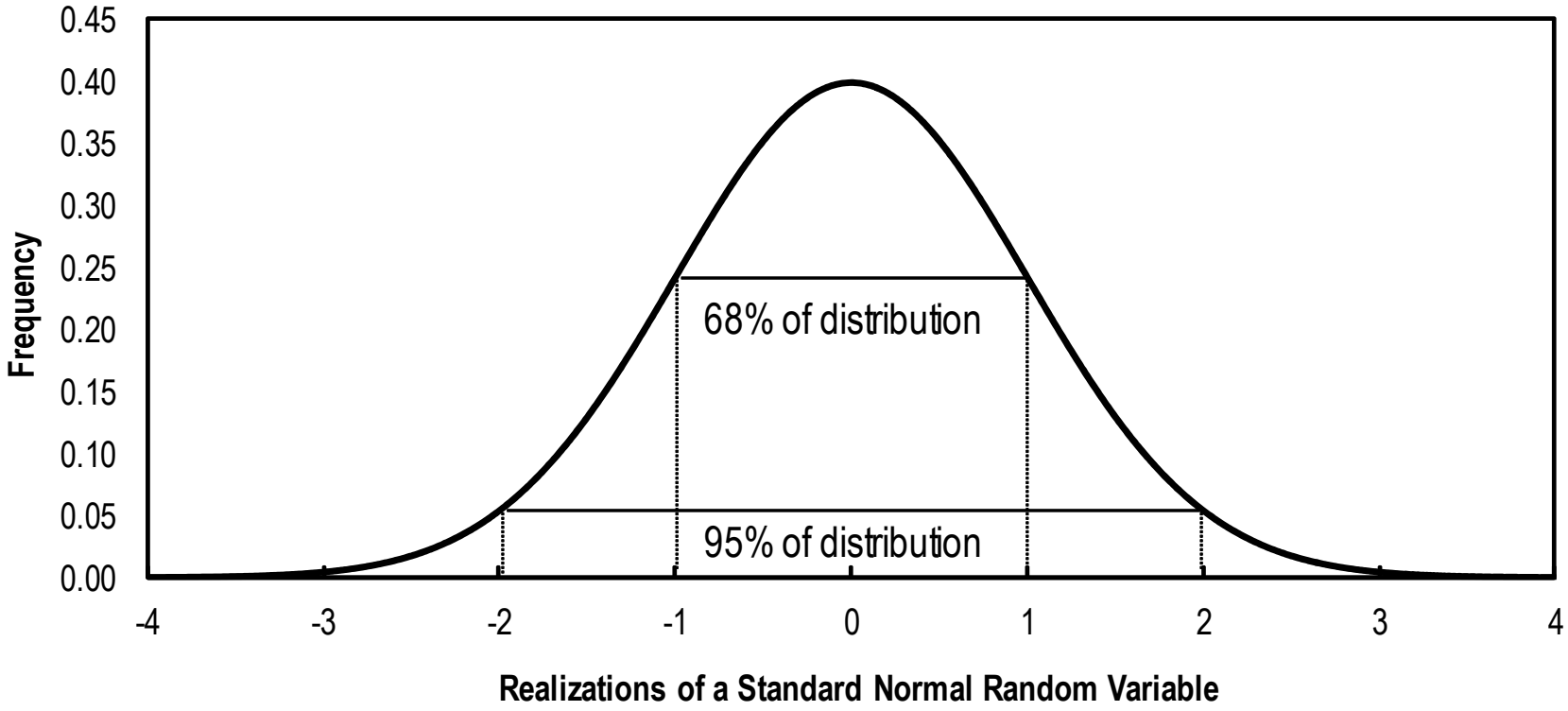
$$RIO: \quad \frac{AR_{jt}}{\hat{\sigma}_j} = \frac{0.2184}{0.0171} = 12.76$$

$$BHP: \quad \frac{AR_{jt}}{\hat{\sigma}_j} = \frac{-0.0562}{0.0145} = -3.88$$

For calculations see *Event studies.xls*, tabs “Rio Tinto UK” and “BHP UK”. Refer to columns J, line 234.

What does a t-test mean?

Normal probability distribution



→ The t-test says that RIO's AR is >12 standard deviations away from the mean, BHP's AR is ~4 standard deviations away from the mean.

T-test and p-values

- What is the probability that $T \neq 0$ just by chance? → Need p-value of the test.
- Probability that test statistic exceeds the estimated value by chance:

$$p_1 = \text{Prob}(t \geq T) = TVERT(|T|, 198, 1)$$

$$p_2 = \text{Prob}(|t| \geq T) = TVERT(|T|, 198, 2)$$

Use TDIST in English version of Excel!

- TVERT (English: TDIST) is Excel-function defined as:
  - TVERT(x,DGF,1) for 1-sided cdf
  - TVERT(x,DGF,2) for 2-sided cdf

x = value of t-statistic;
DGF = degrees of freedom

- The latest version of excel has a new function T.VERT.2S(x,DGF)
- Compare *p* to conventional significance level (1%, 5%, 10%)
- RIO: *p*=0.0000%, BHP: *p*=0.0143%.

For calculations see *Event studies.xls*, tabs "Rio Tinto UK" and "BHP UK". Refer to columns K, line 234.

Testing for significance of CARs

- Suppose we want to test if the CAR from day -3 to day +6 is significant. These are 10 days, so we have:

$$CAR_j(-3,+6) = \sum_{t=-3}^{6} AR_{jt} \overset{H_0}{\sim} N\left(0,\ 10\sigma_j^2\right)$$

- Then our t-test becomes:

$$\frac{CAR(-3,+6)}{\sqrt{10\hat{\sigma}_j^2}} \overset{H_0}{\sim} T(198)$$

$$RIO: \frac{CAR(-3,+6)}{\sqrt{10\hat{\sigma}_j^2}} = \frac{0.2768}{\sqrt{10}\times 0.0171} = 5.1145$$

$$BHP: \frac{CAR(-3,+6)}{\sqrt{10\hat{\sigma}_j^2}} = \frac{-4.28}{\sqrt{10}\times 0.0145} = -0.934$$

For calculations see *Event studies.xls*, tabs "Rio Tinto UK" and "BHP UK". Refer to column H, line 6.

Significance tests for CARs

Rio Tinto (UK)	Days	CAR	t-value	p-value
CAR(0)	1	21.84%	12.760	0.0000%
CAR(-1,0)	2	24.32%	10.048	0.0000%
CAR(0,1)	2	29.84%	12.328	0.0000%
CAR(-1,1)	3	32.32%	10.903	0.0000%
CAR(-3,6)	10	27.68%	5.114	0.0001%

BHP (UK)	Days	CAR	t-value	p-value
CAR(0)	1	-5.62%	-3.879	0.0143%
CAR(-1,0)	2	-4.32%	-2.107	3.6379%
CAR(0,1)	2	-5.29%	-2.579	1.0645%
CAR(-1,1)	3	-3.98%	-1.586	11.4283%
CAR(-3,6)	10	-4.28%	-0.934	35.1476%

For calculations see *Event studies.xls*, tabs “Rio Tinto UK” and “BHP UK”. Refer to columns E-K, lines 1-6.

Testing for *d* days and *N* firms

The general case

- Suppose we have *N* firms in a sample and evaluate CARs for an event window with length *d*. Then:

$$\frac{1}{N}\sum_{j=1}^{j=N} CAR_j \overset{H_0}{\sim} \mathrm{N}\left(0, \frac{d}{N^2}\sum_{j=1}^{N}\sigma_j^2\right)$$

- Then our test-statistic becomes:

$$\frac{\frac{1}{N}\sum_{j=1}^{N} CAR_j}{\sqrt{\frac{d}{N^2}\sum_{j=1}^{N}\hat{\sigma}_j^2}} \overset{H_0}{\sim} \mathrm{N}(0,1)$$

- Note: Even if individual CARs are not normal, the average CAR (numerator) will be for sufficiently large *N*.

Non-parametric rank test

Idea for a test that does not depend on assumptions about the distribution:

- → Under the null hypothesis (no event, some returns are randomly large or small) the distribution of abnormal returns in the event window should be the same as that in the estimation window.
- → Pool the returns from the estimation window and the event window and rank them from largest to smallest
- → Average the ranks for each window separately. Under the null hypothesis, the average rank in the estimation window and the average rank in the event window should be the same.
  - But if there is a significant abnormal return in the event window, then the largest (or smallest) returns will be in the event window, so these returns will have lower (higher) ranks than those in the estimation window.
  - Then the average rank there will be significantly lower (higher).

Formulae for rank test (following Corrado 1989)

- Rank each security *i* 's abnormal returns for *t* = -220,…,+20:

$$K_{it} = rank(AR_{it}), \text{ with } K_{it} > K_{ij} \text{ for } AR_{it} < AR_{ij}$$

- The average rank is defined as one-half plus half the number of observed returns, or 121.
- The rank test substitutes the rank deviation for the abnormal return and the test statistic for one-day *t* and *N* firms becomes:

$$T^{RANK} = \frac{1}{\sigma(K)} \frac{1}{N} \sum_{i=1}^{N} (K_{i,t} - 121)$$

$$\sigma(K) = \sqrt{\frac{1}{241} \sum_{t=-220}^{20} \left(\frac{1}{N} \sum_{i=1}^{N} (K_{i,t} - 121) \right)}$$

- For a multi-period specification with *d* days, sum up the T values and divide with the square root of *d*!

How did competitors react?

- How did the competitors of RIO and BHP react to the merger?
- Two scenarios:
  - Merger improves efficiency of newly merged firm: competitors lose market share, have to reduce prices: stock price drops.
  - Merger reduces competitiveness of the industry: competitors benefit from consolidation, stock price rises.
- Calculate CARs for 6 competing firms in the iron ore industry

Event study for 6 iron ore firms

- Competitors in the iron ore industry
  - VALE
  - Anglo American
  - Kumba Iron Ore
  - MMX Miner
  - Mount Gibson Iron
  - Gindalbie Metals

CARs	CAR	t-value	p-value	Rank test	p-value
CAR(0)	4.40%	3.810	0.0002	-1.9806	4.8788%
CAR(-1,0)	6.46%	3.954	0.0001	-2.5959	1.0019%
CAR(0,1)	6.39%	3.911	0.0001	-2.3561	1.9276%
CAR(-1,1)	8.45%	4.222	0.0000	-2.8998	0.4081%
CAR(-3,6)	4.24%	1.159	0.2477	-0.8408	40.1316%

For calculations see *Event studies.xls*, tab "Summary". Refer to columns A-G, lines 28-35.

Potential problems and further issues

- Overlapping event windows:
  - Abnormal returns cannot be treated as independent when event windows overlap.
  - Serious problem if event date is the same calendar date for all firms.
    - Then use methods that allow for such correlations should be used.
- Variance increase:
  - The method can yield false rejections if the variance in the event window is higher than the variance in the estimation period.
  - This can be the case if the event leads to higher uncertainty about the value of the firm.

Interpreting the results

- Be careful not to extrapolate the results:
  - A positive abnormal return on the announcement day of a merger only shows that announced mergers are profitable.
  - It does not mean that any merger is profitable.
- Not every announced transaction is actually completed.
  - The market reaction includes the probability of the transaction actually taking place.
  - An abnormal return of 2% can be due to a sure gain of 2% or to a gain of 4% with 50% probability.
- We may learn something about the pre-event value of the firm, reaction unrelated to the event.

Conclusion

- Use event study methodology to understand stock prices
- Rigorous technique to understand stock price reactions
- Can be applied to single events or small groups of events:
  - But results then significant only if reaction is large
  - Requires assumptions on distribution
- Avoid ex post rationalizations:
  - Apply statistical tests instead

A final word on the deal

- In November 2008 BHP Billiton surprisingly withdrew its offer for Rio Tinto.
- Stated reasons by BHP Billiton were:
  - The recent decline of prices for raw materials due to the financial crises raises unforeseeable risks.
  - Conditions set by the European Commission to sell part of the company before the takeover
- In December 2009 both companies signed a joint venture agreement covering both companies Western Australian iron ore assets.