# Time-series Econometrics

## Event studies

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# Outline

# Event studies

- Very useful way to examine effects when an event and associated news can be isolated from other developments
- Campbell, Lo and MacKinlay (1997, Ch. 4)
  - Use their notation
  - Returns can be proportional or logarithmic
  - Log returns generally are simpler because return over a N periods is just the sum of the N returns – a linear operation
- A review of the literature is provided by Kothari and Warner (2007, "Econometrics of Events Studies" in *Handbook of Corporate Finance*)
  - There are more recent developments but mostly details

# Overview of event studies

- Event studies examine the effect of some event or set of events on the value of assets
  - Loosely speaking, a t-test of the change in price of some asset
  - Unexpectedly large increase or decrease relative to standard deviation of typical change
- Normal and abnormal return

$$R_t = R_t^n + R_t^a$$

  - where $R_t$ is observed return
  - $R_t^n$ is normal return
    - ★ Normal return is what we observe usually
  - $R_t^a$ is abnormal return, return associated with some event
    - ★ $\mathrm{E}\, R_t^a = 0$ is the unconditional expectation of abnormal return
    - ★ Return with abnormal return is effect of event, $R_t^a \neq 0$ if event affected returns

# Change in asset price

- Effect of news on an asset price
  - News is unexpected
- Get unexpected part of change in asset prices
  - Firms' stock prices
  - Exchange rates
  - Bond prices
- For many of these assets, change in price itself is unexpected
  - If asset prices were random walks, the change itself would be unexpected
  - Frequent trading relative to event window is helpful for the news being reflected in price

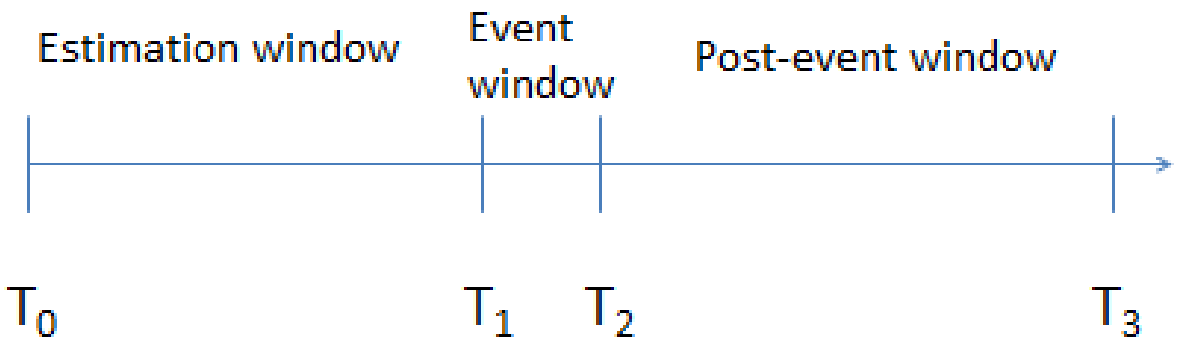
# Types of events

- Earnings announcements
- Insider trading
- Stock splits
- Issuance of new debt
- Borrowing from a bank
- Merger or takeover announcement
- Regulatory changes
  - Can estimate who gains and who loses
  - Examples
    - Banking regulations
    - Pollution regulations

# What is an event?

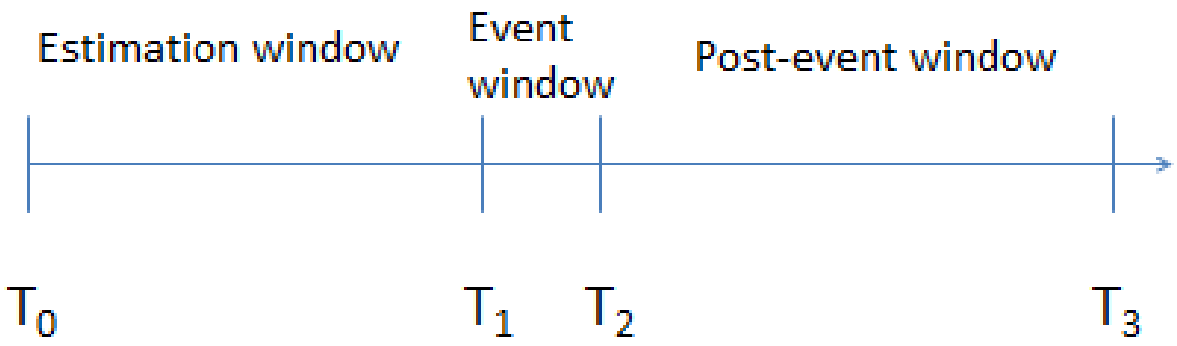
- Some change, development, announcement that may produce a relatively large change in the price of the asset over some period
  - Define an event window – a period over which the event occurs
  - Define an estimation window – a period over which parameters are estimated
  - Want the event window to be short relative to the estimation window
    - ★ Estimation window commonly is 120 trading days (roughly six months)
    - ★ Event window commonly measured over a few days

# Event window




- Have data for a time period from $T_0$ to $T_3$
- $T_0$ is the date at which data start
- $T_3$ is the date at which data end
- $T_1$ is the start of the event window,
  - Start of period when asset price might be affected by news
- $T_2$ is the end of the event window
  - End of period when asset price might be affected by news

# Event window




- Estimation window used to estimate parameters
- Event window used to estimate abnormal price change
- Post-event window used to verify that returns go back to "normal"
  - "Normal" is similar to pre-event window (estimation window)

# Construct measure of normal and abnormal returns

- Normal return is return in estimation window and post-event window
- Abnormal return is return in event window if news affected price
  - "Normal" here just means typical
  - "Abnormal" just means atypical
- Normal and abnormal return

$$R_t = R_t^n + R_t^a$$

  - where $R_t$ is observed return
  - $R_t^n$ is normal return
  - $R_t^a$ is abnormal return
- In estimation window,

$$\mathrm{E}\, R_t^a = 0$$

- In event window, if event affected returns,

$$\mathrm{E}\, R_t^a \neq 0$$

# Estimate abnormal return with constant mean return

- Constant mean expected return, random walk of price with drift, is

$$R_t = \alpha + \varepsilon_t$$

  - where $R_t$ is observed return
  - $\alpha$ is the mean return
  - $\varepsilon_t$ is the "abnormal return"
    - ★ Mean is zero in estimation period
  - Estimate $\alpha$ in estimation period, giving $\widehat{\alpha}$
- In estimation window, by construction, average abnormal return is

$$\bar{R}_t^a = \bar{R}_t - \widehat{\alpha} = 0$$

- In event window

$$R_t^a = R_t - \widehat{\alpha}$$

  - Test whether $\mathrm{E}\, R_t^a = 0$

# Estimate abnormal return by market model

- Common model of returns reflects changes in the overall market, the so-called "market model"

$$R_t = \alpha + \beta R_t^m + \varepsilon_t$$

  - where $R_t$ is observed return
  - $R_t^m$ is the market return
  - $\alpha$ and $\beta$ are the parameters estimated by least squares
  - $\varepsilon_t$ is the "abnormal return"
    - ★ Mean of $\varepsilon_t$ is zero in estimation period
  - Estimate $\alpha$ and $\beta$ in estimation period, giving $\widehat{\alpha}$ and $\widehat{\beta}$
- In estimation window, by construction, where the bar indicates the average

$$\bar{R}_t^a = \bar{R}_t - \widehat{\alpha} - \widehat{\beta}\bar{R}_t^m = 0$$

- In event window

$$R_t^a = R_t - \widehat{\alpha} - \widehat{\beta} R_t^m$$

  - Test whether $\mathrm{E}\, R_t^a = 0$

# Estimate abnormal return by CAPM

- Another obvious possible model of normal returns is the CAPM

$$R_t - R_t^f = \alpha + \beta \left( R_t^m - R_t^f \right) + \varepsilon_t$$

  - where $R_t$ is observed return
  - $R_t^m$ is the market return and $R_t^f$ is the riskfree rate
  - $\alpha$ and $\beta$ are the parameters in the CAPM
    - ★ Estimate by ordinary least squares
  - $\varepsilon_t$ is the "abnormal return"
    - ★ Mean of $\varepsilon_t$ is zero by construction in estimation period
  - Estimate $\alpha$ and $\beta$ in estimation period, giving $\widehat{\alpha}$ and $\widehat{\beta}$
- In estimation window, by construction

$$\bar{R}_t^a = \bar{R}_t - \bar{R}_t^f - \widehat{\alpha} - \widehat{\beta} \left( \bar{R}_t^m - \bar{R}_t^f \right) = 0$$

- In event window

$$R_t^a = R_t - R_t^f - \widehat{\alpha} - \widehat{\beta} \left( R_t^m - R_t^f \right)$$

  - Test whether $\mathrm{E}\, R_t^a = 0$

# Aggregation

- Can aggregate over time or across firms or both
- Aggregate over time to get "cumulative abnormal return"
  - Change occurs over time, possibly over days
- Aggregate across same event for multiple firms
  - Need not occur on the same day for each firm
- Aggregation leads to no fundamental issues if normal and abnormal returns uncorrelated

# Example: Variance of cumulated or averaged returns

- Cumulate or average returns over time from $T_1$ to $T_2$, $T^e = T_2 - T_1 + 1$ observations
- Cumulated returns from $T_1$ to $T_2$

$$\sum_{t=T_1}^{T_2} R_t^a$$

- If returns are uncorrelated over time with a constant variance

$$\text{Var}\left[\sum_{t=T_1}^{T_2} R_t^a\right] = \sum_{t=T_1}^{T_2} \text{Var}\left[R_t^a\right] = T^e \,\text{Var}\left[R^a\right]$$

$$\text{SD}\left[\sum_{t=T_1}^{T_2} R_t^a\right] = \sqrt{T^e}\,\text{SD}\left[R^a\right]$$

# Example: Variance of cumulated or averaged returns

- If returns are uncorrelated over time with a constant variance
- The null hypothesis is that, in the event window,

$$\mathrm{E}\, R_t^a = 0$$

which implies

$$\mathrm{E} \sum_{t=T_1}^{T_2} R_t^a = 0$$

- Under this null hypothesis

$$\frac{\sum_{t=T_1}^{T_2} R_t^a}{\sqrt{T^e}\,\mathrm{SD}\left[R^a\right]} \sim t \text{ with } T^e - p \text{ degrees of freedom}$$

where $p$ is the number of parameters estimated

# Regressions for event studies

- Regressions can be used in event studies instead of t-tests
  - Useful if there are multiple events
- Suppose have multiple events irregularly spaced over time
  - Compute mulitple t-tests, sometimes with overlapping data and sometimes not?
- Run a regression of the return on dummy variables for each event
- Can compute test statistics for multiple days, etc. in the obvious ways from OLS regressions
- Can use abnormal return on left of regression or can put variable, such as market return on right-hand side of regression
- Easily can test whether a type of event has non-zero coefficients for all such events without assuming they have the same effect on the return

# Uses of event studies

- Is there insider trading before an announcement?
  - Stock price changes before an announcement
- Effects of short-sale restrictions on stock prices
- What are effects of events concerning firms' financing?
  - Stock splits
  - Loan financing
- Which firms gain and which lose from a change in regulation?

# Possible problems

- When did the event become known?
- There may be other events affecting returns on the same days: confounding events
- Event date may not be independent of developments concerning firm
  - For example, low stock returns may cause a stock buyback
- Heteroskedasticity
  - Changes in variance over time

# Summary

- At their simplest, event studies use relatively simple statistics
- Maybe partly because of that, they can be quite informative
- Trickiest issues usually are deciding when to date events and being sure there are not counfounding events