# Event Study

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# Broad Lesson Plan

# Learning Objectives

- Discuss the notion and purposes of event study
- Elaborate the concepts of abnormal return (AR) and cumulative abnormal return (CAR)
- Derive the distributions of AR and CAR
- Discuss permanent versus temporary effect of the event
- Discuss information leakage
- Examine an event study as a case study

# Purpose of Event Study

✓ Event studies allow you to estimate how asset prices, i.e., prices of stocks, FX, bonds, or CDS, react to **announcements** of economic events that include new information relevant for the value of the underlying assets.

✓ Is market efficient in reflecting the information in an event?

✓ If strong-form market efficiency hypothesis is true, then any significant return deviations before the time of public announcement may provide evidence of **insider information leakage**.

✓ Does the event have positive, negative, or neutral impact on returns?

# General Idea of Event Study

✓ In general, an event study is a **systematic examination of the average impact** of a certain event on the price of a certain type of asset.

✓ It is very important to **exclude all events announced jointly with another piece of news**.

✓ Compare the asset price that occurred as a result of the announcement of the event (the **realized return**) with a hypothetical asset price that would have occurred if no event had been announced (the **expected return**).

✓ The **difference** between the realized and the expected return, called the **abnormal return**, can be attributed to the event and be tested for statistical significance.

# Structure of an Event Study

✓ Event Date: business day/trading session immediately after the announcement

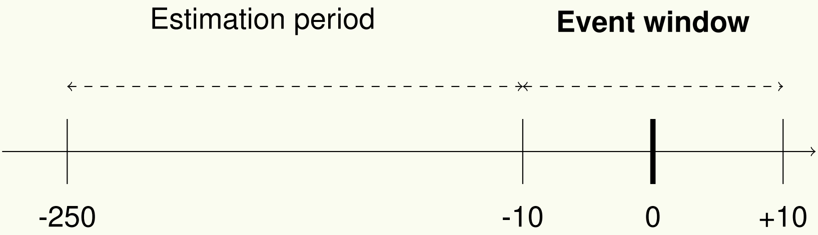
✓ Measurement or Estimation Period: $t = -250$ days up to $t = -11$ days from the event date

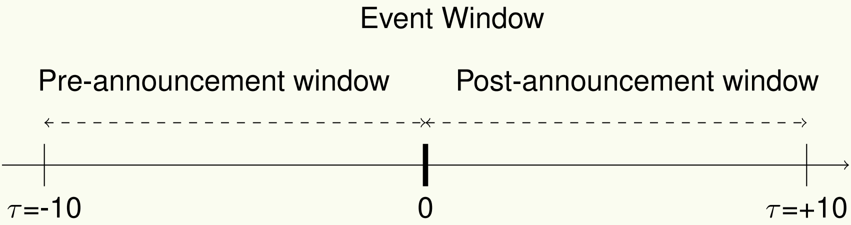
✓ **Event Window**: $\pm 10$ days surrounding the event date

✓ Pre-event window: $\tau = -1$ to $\tau = -10$ business days from the event date

✓ Post-event window: $\tau = 1$ to $\tau = 10$ business days from the event date

# Periods and Windows for Returns



# Important Ingredient of Event Study

- Each event must be of the same nature. For example, positive earnings surprise is different from negative earnings surprise.
- **The announcement date** must be known and free of mistakes.
- The absolute calendar date is not important, only the dates relative to announcement date matters.
- When the announcement occurs after the market has closed, the announcement date is the next business or trading day.

# Benchmarks

- **Market Model**

$$\begin{aligned} r_{it} &= \alpha_i + \beta_i r_{mt} + e_{it} \quad \text{for } t = -L-10 \text{ to } -11 \\ \text{AR}_{i\tau} &= r_{i\tau} - \hat{\alpha}_i - \hat{\beta}_i r_{m\tau} \quad \text{for } \tau = -10 \text{ to } \tau = 10 \end{aligned}$$

- **CAPM**

$$\begin{aligned} r_{it} &= r_{ft} + \beta_i (r_{mt} - r_{ft}) + u_{it} \quad \text{for } t = -L-10 \text{ to } -11 \\ \text{AR}_{i\tau} &= r_{i\tau} - \Big( r_{f\tau} + \hat{\beta}_i (r_{m\tau} - r_{f\tau}) \Big) \quad \text{for } \tau = -10 \text{ to } \tau = 10 \end{aligned}$$

- **Market Adjusted Excess Return Model**

$$\text{AR}_{i\tau} = r_{i\tau} - r_{m\tau}$$

- **Mean Adjusted Excess Return**

$$\text{AR}_{i\tau} = r_{i\tau} - \overline{r}_i \,, \quad \text{where} \quad \overline{r}_i = \frac{1}{L} \sum_{t=-L-10}^{-11} r_{it}$$

# More on Market Model

- The assumptions are, for a particular information event $i$,
  1. $\mathbb{C}\big(r_{mt}, e_{it}\big) = 0$
  2. $\mathbb{V}\big(e_{it}\big) = \sigma_i^2$
  3. $\mathbb{C}\big(e_{it}, e_{it-k}\big) = 0$
- The OLS regression for data set $t = -250$ to $t = -11$, will yield BLUE $\widehat{\alpha}_i$ and $\widehat{\beta}_i$ that are also consistent.
- The following estimate for $\sigma_i^2$ is unbiased and consistent:

$$\widehat{\sigma}_i^2 = \frac{1}{L-2} \sum_{t=-L-10}^{-11} \big(r_{it} - \widehat{\alpha}_i - \widehat{\beta}_i\, r_{mt}\big)^2 = \frac{1}{L-2} \sum_{t=-L-10}^{-11} \widehat{e}_{it}^{\,2}\,,$$

where $L$ is the number of log returns in the measurement window. $L = 240$ is hyper-parametrically ideal.

# Hypothesis Test in Event Study

✓ Significant information in the event announcement is taken to be unanticipated news that causes the market to re-evaluate the stock's

(a) expected future earnings (thus also dividends)

(b) risk-adjusted discount rate

✓ With significant information impact, the expected value of $\text{AR}_{i\tau}$ is non-zero, conditional on market condition up to and including those at $\tau$.

✓ Average abnormal returns over the event window would then be significantly different from zero.

✓ Thus for the first 3 benchmarks, the null hypothesis is, for $\tau = -10$ to $\tau = 10$,

$$\mathbb{E}\big(\text{AR}_{i\tau} \big| r_{m\tau}\big) = 0.$$

# Simple Linear Regression

- Slope and intercept estimators

$$\widehat{b} = \frac{S_{xy}}{S_{xx}} := \frac{\displaystyle\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\displaystyle\sum_{i=1}^{n}(x_i - \overline{x})^2}; \qquad \widehat{a} = \overline{y} - \widehat{b}\,\overline{x}.$$

- OLS distribution is

$$\begin{pmatrix} \widehat{a} \\ \widehat{b} \end{pmatrix} \overset{d}{\sim} \mathcal{N}\left( \begin{pmatrix} a \\ b \end{pmatrix}, \begin{pmatrix} \sigma_u^2\left(\dfrac{1}{n} + \dfrac{\overline{x}^2}{S_{xx}}\right) & -\sigma_u^2\dfrac{\overline{x}}{S_{xx}} \\ -\sigma_u^2\dfrac{\overline{x}}{S_{xx}} & \dfrac{\sigma_u^2}{S_{xx}} \end{pmatrix} \right).$$

# Conditional Mean and Variance for Market Model

$$\begin{aligned}
\mathbb{E}\big(\mathsf{AR}_{i\tau}|r_{m\tau}\big) &= \mathbb{E}\big(r_{i\tau}|r_{m\tau}\big) - \mathbb{E}\big(\hat{\alpha}_i|r_{m\tau}\big) - r_{m\tau}\mathbb{E}\big(\hat{\beta}_i|r_{m\tau}\big)\\
&= \mathbb{E}\big(r_{i\tau}|r_{m\tau}\big) - \hat{\alpha}_i - \hat{\beta}_i r_{m\tau} = 0
\end{aligned}$$

$$\begin{aligned}
\mathbb{V}\big(\mathsf{AR}_{i\tau}|r_{m\tau}\big) &= \mathbb{V}\big(r_{i\tau}|r_{m\tau}\big) + \mathbb{V}\big(\hat{\alpha}_i|r_{m\tau}\big) + r_{m\tau}^2\mathbb{V}\big(\hat{\beta}_i|r_{m\tau}\big)\\
&\quad +2r_{m\tau}\mathbb{C}\big(\hat{\alpha}_i,\hat{\beta}_i|r_{m\tau}\big) - 2\mathbb{C}\big(r_{i\tau},\hat{\alpha}_i|r_{m\tau}\big) - 2r_{m\tau}\mathbb{C}\big(r_{i\tau},\hat{\beta}_i|r_{m\tau}\big)\\
&= \sigma_i^2 + \sigma_i^2\left(\frac{1}{L} + \frac{\overline{r}_m^2}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2}\right)\\
&\quad +\sigma_i^2\frac{r_{m\tau}^2}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2} - 2\sigma_i^2\frac{r_{m\tau}\overline{r}_m}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2}\\
&= \sigma_i^2\left(1+\frac{1}{L}+\frac{(r_{m\tau}-\overline{r}_m)^2}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2}\right)
\end{aligned}$$

where $\overline{r}_m = \dfrac{1}{L}\displaystyle\sum_{t=-L-10}^{-11} r_{mt}$.

# Distribution of $\mathrm{AR}_{i\tau}$ and SAR

★ The distribution of $\mathrm{AR}_{i\tau}$ is normal

$$\mathrm{AR}_{i\tau} \big| r_{m\tau} \overset{d}{\sim} N\left(0, \sigma_i^2 \left(1 + \frac{1}{L} + \frac{(r_{m\tau} - \overline{r}_m)^2}{\sum_{t=-L-10}^{-11} (r_{mt} - \overline{r}_m)^2}\right)\right).$$

★ The standardized abnormal return (SAR) is defined as

$$\frac{\mathrm{AR}_{i\tau}}{\widehat{\sigma}_i}.$$

★ When $L$ is large,

$$\frac{\mathrm{AR}_{i\tau}}{\widehat{\sigma}_i} \sim N(0, 1).$$

# Estimations with the Market Model as Benchmark

- Estimate the average market return and the variance of estimation errors by

$$\bar{r}_m = \frac{1}{L} \sum_{t=-L-10}^{-11} r_{mt}; \qquad \widehat{\sigma}_i^2 = \frac{1}{L-2} \sum_{t=-L-10}^{-11} \widehat{e}_t^2.$$

- Thus, the standard error is

$$\text{s.e.} = \widehat{\sigma}_i \sqrt{1 + \frac{1}{L} + \frac{(r_{m\tau} - \bar{r}_m)^2}{\sum_{t=-L-10}^{-11} (r_{mt} - \bar{r}_m)^2}}.$$

and the $t$ statistic for the null hypothesis of zero abnormal return at time $\tau$ is

$$\frac{\text{AR}_{i\tau}}{\text{s.e.}} \overset{d}{\sim} t_{L-2}.$$

Note that s.e. is different for different $\tau$.

# Cumulative Abnormal Return

- For $\tau_k$ ranging from $-10$ to $10$, the cumulative abnormal return (CAR) is

$$\text{CAR}_i(\tau_k) = \sum_{\tau=-10}^{\tau_k} \text{AR}_{i\tau}.$$

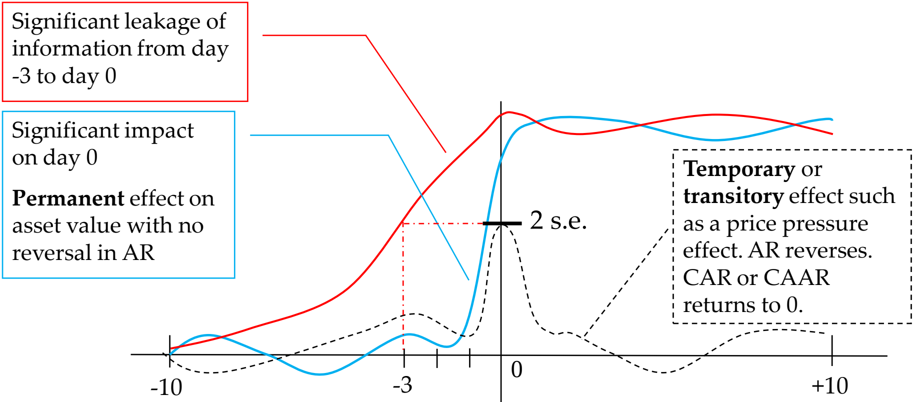
- The time series of $\text{CAR}_i(\tau_k)$ may be construed as the market adjusted "price" series.
- The conditional variance of $\text{CAR}_i(\tau_k)$ is

$$\mathbb{V}\big(\text{CAR}_i(\tau_k)|r_{m\tau_k},\dots\big) = \sum_{\tau=-10}^{\tau_k} \mathbb{V}\big(\text{AR}_{i\tau}|r_{m\tau}\big) \approx \big(\tau_k - (-10) + 1\big)\sigma_i^2.$$

- So the distribution of $\text{CAR}_i(\tau_k)$, conditional on the market returns from $\tau = -10$ up to $\tau_k$, is

$$\text{CAR}_i(\tau_k)\Big|r_{m\tau_k},\dots \overset{d}{\sim} N\Big(0,\, \sigma_i^2\big(\tau_k + 11\big)\Big).$$

# Permanent versus Temporary Effect Seen in CAR



# Average Abnormal Return

- If there are $N$ firm-events, at any time $\tau$ within the event window, the average abnormal return is

$$\text{AAR}_\tau = \frac{1}{N}\sum_{i=1}^{N}\text{AR}_{i\tau}.$$

- Assuming independence of disturbance across events because they are not clustered,

$$\mathbb{V}\big(\text{AAR}_\tau | r_{m\tau}\big) = \frac{1}{N^2}\sum_{i=1}^{N}\mathbb{V}\big(\text{AR}_{i\tau}\big).$$

- So the distribution for $\text{AAR}_\tau \big| r_{m\tau}$ is

$$\text{AAR}_\tau \big| r_{m\tau} \overset{d}{\sim} N\left(0\,,\,\frac{1}{N^2}\sum_{i=1}^{N}\mathbb{V}\big(\text{AR}_{i\tau}\big)\right).$$

# Cumulative Average Abnormal Return

® For $\tau_k$ ranging from $-10$ to $10$, the cumulative average abnormal return (CAAR) is

$$\begin{aligned}\mathsf{CAAR}(\tau_k) &= \frac{1}{N}\sum_{i=1}^{N}\sum_{\tau=-10}^{\tau_k}\mathsf{AR}_{i\tau}\\ &= \sum_{\tau=-10}^{\tau_k}\frac{1}{N}\sum_{i=1}^{N}\mathsf{AR}_{i\tau}\\ &= \sum_{\tau=-10}^{\tau_k}\mathsf{AAR}_{\tau}.\end{aligned}$$

® The conditional variance of $\mathsf{CAAR}(\tau_k)$ is

$$\mathbb{V}\big(\mathsf{CAAR}(\tau_k)|r_{m\tau_k},\dots\big) = \sum_{\tau=-10}^{\tau_k}\mathbb{V}\big(\mathsf{AAR}_{\tau}\big).$$

# Sample Variance of $\text{AAR}_\tau$

☒ The event study tests are based on the null hypothesis that the return process' mean level and variance remain constant.

☒ Rejection of the null could suggest that either the mean changes or the volatility changes (or both change) due to the event announcement.

☒ To test only whether there is any **mean level of AAR** while not fixing volatility at the level of the estimation period, then we can use the sample variance of AAR during the event window, i.e.

$$\sigma^2(\text{AAR}) = \frac{1}{20} \sum_{\tau=1}^{21} \left(\text{AAR}_\tau - \overline{\text{AAR}}_\tau\right)^2,$$

to construct the test statistic

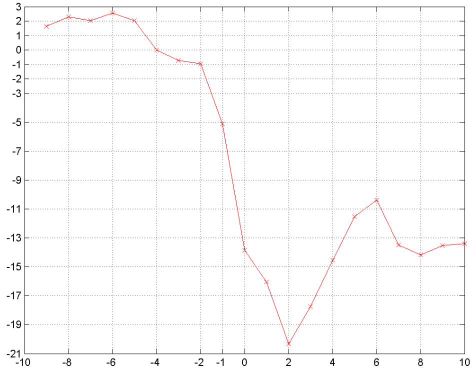
$$\frac{\text{AAR}_\tau}{\sigma(\text{AAR})} \overset{d}{\sim} t_{20}.$$

# Case Study: AIG

## Ⓢ AIG Seeks Short-Term Financing

Monday, 15 Sep 2008 12:17am EDT

Reuters: AIG has made an unprecedented approach to the Federal Reserve seeking $40 billion in short-term financing.




t-Statistics for CAR

# Takeaways

❋ Event study has become a standard financial econometrics for analyzing the effects of an announcement.

❋ It is crucial that the announcement date (and time) is known, and that the announcement is not contaminated by other news.

❋ Essentially, abnormal return is a long-short strategy.

❋ Therefore, from a practical standpoint, it would be better to use the relevant **ETF** or **index futures** in constructing a benchmark.

❋ Even financial market regulators use event study to assess the economic impact of laws and changes in regulation and to detect insider trading.