Event Study Analysis: CLM Chapter 4

Definition:

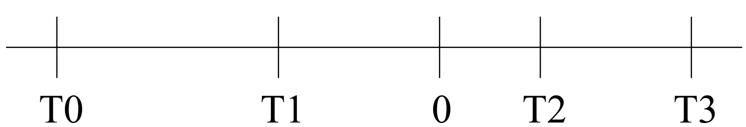
- An event study attempts to measure the valuation effects of a corporate event, such as a merger or earnings announcement, by examining the response of the stock-price around the announcement of the event.
- One underlying assumption is that the market processes information about the event in an efficient and unbiased manner (more on this later).

Event Study Analysis

- The steps for an event study are as follows:
  - Event Definition
  - Selection Criteria
  - Normal and Abnormal Return Measurement
  - Estimation Procedure
  - Testing Procedure
  - Empirical Results
  - Interpretation

Event Study Analysis

- The time line for a typical event study is shown below in event time:



- The interval T0-T1is the estimation period
- The interval T1-T2 is the event window
- Time 0 is the event date in calendar time
- The interval T2-T3 is the post-event window
- There is often a gap between the estimation and event periods

Models for measuring normal performance

- In an event study we wish to calculate the abnormal performance associated with an event. To do so, we need a model for normal returns.
  - For example: Suppose a firm announces earnings and the stock price rises by 3%, but the market also went up 2% that day. How much of the 3% rise should be attributed to the announcement of earnings.
    - Fortunately, over short event windows (one or two days) the choice of normal return models usually has little effect on the results

Statistical or economic models for normal returns?

- Statistical models of returns are derived purely from statistical assumptions about the behavior of returns
- Economic models apply restrictions to a statistical model that result from assumptions about investor behavior motivated by theory (i.e., CAPM)
  - If the restrictions are true, we can calculate more precise measures of abnormal returns.

Statistical models of returns

- Assume that returns on stocks are jointly multivariate normal and are distributed iid through time.
- A1: Let $\mathbf{R_t}$ be an (Nx1) vector of asset returns for calendar time period t. R_t is independently multivariate normally distributed with mean μ and covariance matrix Ω for all t.
  - This assumption is sufficient for constant mean return and market model return models to be correctly specified.

Constant mean return model

- For each asset i, the constant mean return model assumes that asset returns are given by:

$$R_{it} = \mu_i + \xi_{it}, \; where$$
$$E[\xi_{it}] = 0 \;\; and \;\; Var[\xi_{it}] = \sigma^2_{\xi i}$$

- Brown and Warner (1980, 1985) find that the simple mean returns model often yields results similar to those of more sophisticated models because the variance of abnormal returns is not reduced much by choosing a more sophisticated model

Market model (the most popular in practice)

- For each asset i, the market model assumes that asset returns are given by:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \text{ , } where$$
$$E[\varepsilon_{it}] = 0 \;\; and \;\; Var[\varepsilon_{it}] = \sigma^2_{\varepsilon i}$$

- In this model R_{mt} is the return on the market portfolio, and the model's linear specification follows from the assumed join normality of returns.
  - In applications, a broad-based stock index, such as the S&P 500 or the CRSP equal- or value-weighted indices are used as the market portfolio

Market model

- Note that when $\beta_i = 0$, the market model collapses to the constant mean return model
- The market model represents a potential improvement over the constant mean return model by removing the portion of the return that is related to the return on the market portfolio
- The benefit of using the market model will depend on the R^2 of the regression
  - The higher the R^2, the greater is the reduction in the variance of abnormal returns, which increases the power to detect abnormal performance

Estimating the market model

- First, index the returns for all securities in event time, then use data from the estimation window (T_0+1 to T_1) to estimate the parameters of the market model for each security in the sample using OLS

$$R_i = X_i\theta_i + \varepsilon_i \,, where$$
$$R_i = [R_{iT0+1} \ldots R_{iT1}]' \,,$$
$$X_i = [i\, R_m], \; and \; \theta_i = [\alpha_i \; \beta_i]'$$

- And where the length of the estimation period is L_1

Estimating the market model

- Using the properties of OLS, the estimated parameters of the market model are:

$$\hat{\theta}_i = \left(X_i' X_i\right)^{-1} X_i' R_i$$
$$\hat{\sigma}^2_{\varepsilon i} = \frac{1}{L_1 - 2} \hat{\varepsilon}_i' \hat{\varepsilon}_i$$
$$\hat{\varepsilon}_i = R_i - X_i \hat{\theta}_i$$
$$Var[\hat{\theta}_i] = \left(X_i' X_i\right)^{-1} \sigma^2_{\varepsilon i}$$

Statistical properties of abnormal returns

- Next, use the parameter estimates of the market model from the estimation period to calculate abnormal returns over the event window period (T_1+1 to T_2). The event window is of length L_2. The vector of abnormal returns from the event window is given by:

$$\hat{\varepsilon}_i^* = R_i^* - \hat{\alpha}_i i - \hat{\beta}_i R_m^*$$
$$= R_i^* - X_i^* \hat{\theta}_i \text{, where}$$
$$R_i^* = [R_{iT1+1} \ldots R_{iT2}]'$$
$$X_i^* = [i\, R_m^*], \text{and}\, \hat{\theta}_i = [\hat{\alpha}_i\ \hat{\beta}_i]$$

Statistical properties of abnormal returns

- Conditional on the market return over the event window and under the null hypothesis that the event has no effect on stock prices, the abnormal returns will be jointly normally distributed with:

$$E[\hat{\varepsilon}_i^* \mid X_i^*] = 0, \text{and}$$
$$V_i = E[\hat{\varepsilon}_i^* \hat{\varepsilon}_i^{*'} \mid X_i^*] = I\sigma_{\varepsilon i}^2 + X_i^* \left(X_i' X_i\right)^{-1} X_i^{*'} \sigma_{\varepsilon i}^2,$$
$$\text{where } I \text{ is the } (L_2 \times L_2) \text{ identity matrix}$$

Statistical properties of abnormal returns

- The conditional covariance matrix, V, consists of two parts:
  – 1) $I\sigma^2_{\varepsilon i}$
  – 2) $X_i^*\left(X_i'X_i\right)^{-1}X_i^{*'}\sigma^2_{\varepsilon i}$

- The first part is the variance due to future disturbances and the second is the additional variance induced from sampling error in the parameter estimates.
  – The second term approaches zero asymptotically as the length of the estimation period increases.
  – In finite samples the sampling error induces serial correlation in the abnormal returns

Aggregation of abnormal returns

- The abnormal return observations must be aggregated to make overall inferences regarding the event of interest
  – Aggregation through time and aggregation across securities
  – For example, suppose we are examining the effect of equity issues on stock prices. Often the event window is the day of and day following the announcement in order to account for the fact that investors may not become aware of the event immediately

- Define $CAR_i(\tau_1, \tau_2)$ to be the cumulative abnormal return for security i over the time interval (τ_1, τ_2)

Aggregating abnormal returns

- Let γ be an (L_2 X 1) vector with ones in positions τ_1 to τ_2 and zeros elsewhere. Then we have:

$$CAR_i(\tau_1,\tau_2) = \gamma'\hat{\varepsilon}_i^*, \ and$$
$$Var[CAR_i(\tau_1,\tau_2)] = \sigma_i^2(\tau_1,\tau_2) = \gamma' V_i \gamma$$

- Under the null of no abnormal performance:

$$CAR_i(\tau_1,\tau_2) = \gamma'\hat{\varepsilon}_i^* \sim N(0,\sigma_i^2(\tau_1,\tau_2))$$

Testing the hypothesis that abnormal return equals zero for a single security

- Define the standardized cumulative abnormal return as:

$$SCAR_i(\tau_1,\tau_2) = \frac{CAR_i(\tau_1,\tau_2)}{\hat{\sigma}_i(\tau_1,\tau_2)}, where$$
$$\hat{\sigma}_i^2(\tau_1,\tau_2) \ is\ calculated\ based\ on\ \hat{\sigma}_{\varepsilon i}^2$$

- Under the null, $SCAR_i$ is distributed Student t with L_1-2 degrees of freedom:

$$E[SCAR_i] = 0$$
$$Var[SCAR_i] = \frac{L_1 - 2}{L_1 - 4}$$

Testing the hypothesis that the average abnormal return equals zero for many securities

- Assumptions
  - No correlation across the abnormal returns of different securities (will not generally be true if events cluster in calendar time)
  - With no clustering and the maintained distributional assumptions the abnormal returns across securities will be independent
- Given a sample of N events, define the average abnormal return and its variance as:

$$\bar{\varepsilon}^* = \frac{1}{N}\sum_{i=1}^{N}\hat{\varepsilon}_i^*$$

$$Var[\bar{\varepsilon}^*] = V = \frac{1}{N^2}\sum_{i=1}^{N}V_i$$

Testing the hypothesis that the average abnormal return equals zero for many securities

- Aggregating in time across the event window, define the cumulative average abnormal return as:

$$\overline{CAR}(\tau_1,\tau_2) = \gamma'\bar{\varepsilon}^*, \; and$$

$$Var[\overline{CAR}(\tau_1,\tau_2)] = \bar{\sigma}^2(\tau_1,\tau_2) = \gamma' V\gamma$$

- where γ is an (L_2 X 1) vector with ones in positions τ_1 to τ_2 and zeros elsewhere
- Question: Derive the cumulative average abnormal return and its variance as a function of the individual security CARs

Testing the hypothesis that the average abnormal return equals zero for many securities

- Under the null and the assumption that the individual security CARs are independent:

$$\overline{CAR}(\tau_1,\tau_2) \sim N(0,\bar{\sigma}^2(\tau_1,\tau_2))$$

- In practice, since the variance is unknown, we replace the known variance with its estimate:

$$\hat{\bar{\sigma}}^2(\tau_1,\tau_2) = \frac{1}{N^2}\sum_{i=1}^{N}\hat{\sigma}_i^2(\tau_1,\tau_2)$$

Testing the hypothesis that the average abnormal return equals zero for many securities

- The test statistic for testing whether the cumulative average abnormal return equals zero is then:

$$J_1 = \frac{\overline{CAR}(\tau_1,\tau_2)}{[\hat{\bar{\sigma}}^2(\tau_1,\tau_2)]^{\frac{1}{2}}} \overset{a}{\sim} N(0,1)$$

- Alternatively, a test statistic that gives equal weight to each security's SCAR is:

$$J_2 = \left(\frac{N(L_1-4)}{L_1-2}\right)^{\frac{1}{2}} \overline{SCAR}(\tau_1,\tau_2) \overset{a}{\sim} N(0,1), \textit{where}$$

$$\overline{SCAR}(\tau_1,\tau_2) = \frac{1}{N}\sum_{i=1}^{N} SCAR_i(\tau_1,\tau_2)$$

Testing the hypothesis that the average abnormal return equals zero for many securities

- One should choose the test statistic that has higher power
  - If the true abnormal return is constant across securities then we should give more weight to events with lower abnormal return variance. This is what J_2 does
  - If the true abnormal return is larger for securities with higher variance then we should give equal weight to the cumulative abnormal return of each security. This is what J_1 does
  - In practice, over short event windows, the results are not likely to be sensitive to the choice

Conditional Event Study Methods (Prabhala, 1997 RFS)

- Event studies have two purposes
- 1) To test for the existence of an information effect (the impact of an event on the announcing firm's value)
- 2) To identify factors that explain changes in firm value on the event date

- The traditional event study methodology (e.g., Fama Fisher, Jensen, and Roll (1969), Brown and Warner (1980)) has been criticized (e.g., Acharaya (1988, 1993), Eckbo, Maksimovic, and Williams (1990))

Conditional Event Study Methods (Prabhala, 1997 RFS)

- The traditional event study methodology (e.g., Fama Fisher, Jensen, and Roll (1969), Brown and Warner (1980)) has been criticized (e.g., Acharaya (1988, 1993), Eckbo, Maksimovic, and Williams (1990))
- What factors do you think should lead stock prices to move on event days?
- Consider, for example, what happens to stock prices when the fed raises interest rates

New Information Moves Prices

- Even if corporate events are not voluntary, only new information should move prices.
- But suppose events are *voluntary*.
- The fact that the firm chooses to announce at a particular time conveys information.
- Presumably, they are going to announce only at a time most favorable. This introduces a truncation bias.
- When events are modeled accounting for the firm's choice to announce some event, the resulting specifications are typically nonlinear cross-sectional regressions, not the simple linear specifications typically used.
- Prabhala (1997) details how this works.

Prabhala's Results

- Under some statistical assumptions:
  - The usual procedure of testing for an information effect by examining the statistical significance of the average CAR is well-specified
  - The conventional linear cross-sectional regression of CAR's on explanatory variables yields parameter estimates that are proportional to the true conditional model parameters
- Prabhala suggests that the choice between traditional and conditional specifications depends on whether one has a sample of nonevent data (firm's that were partially anticipated to announce and event, but did not). With nonevent data, the conditional models provide more powerful tests.

Long Run Event Studies – The Issues

- What are the sources of bias in long-run event studies?
  - CAR vs buy-and-hold returns
  - Getting the benchmark index wrong
    - Indices have new listings over the long horizon.
    - Indices (e.g. EW mkt) are rebalanced.
    - Long-run returns are positively skewed.
  - Getting the asset pricing model wrong
    - Small mistakes lead to big mistakes in abnormal return assessments.

Calculating Long-run Returns

- Convention:
  - Sum monthly or daily returns over time
  - Let R_{it} as the month *t* sample return
  - Let $E(R_{it})$ be the associated expected return
  - $AR_{it} = R_{it} - E(R_{it})$
  - $CAR = \sum Ar_{it}$
- In contrast
  - $BHAR = \prod(1+R_{it}) - \prod(1+E(R_{it}))$

CAR vs. BHAR

- CAR does not consider compounding
- CAR uses arithmetic rather than geometric average.
- Figure 1 in Barber and Lyon illustrates the differences.
  - For BHAR close to zero (and below), CAR is higher
  - For large BHAR, CAR is much lower.
- Conceptually at least, BHAR looks better.
- Note that for short horizon abnormal returns, there's really no problem.

Other Biases – New listings

- If newly listed firms underperform market averages (Ritter 1991), then the market return will be biased down and CARs will be biased upward. (new listing bias)
- If you look at the data, it looks like most existing firms beat the market.

Drawbacks of BHARS

- Skewness
  - Long positive tail - sample firms can have really high returns and if you average in one of these, get positive CAR, but a very high sample standard deviation.
  - If you *don't* have one of these in your sample, you'll get a low sample standard deviation.
  - It turns out that if you repeatedly sample from a chi-squared(1) distribution (mean 1), you reject (5% level) that the mean is 1 in favor of the mean less than 1 6.6% if the time, but never reject for the opposite reason.
  - Seems to affect BHARs more than CARs.

Rebalancing

- Only affects BHARs because returns are summed with CARs.
  - Problem is that poorly performing firms one month subsequently perform well.
  - The EW index overweights these and therefore the performance of the EW index is too good.

What should you use for "normal" returns

- Reference portfolio?
  - We have already discussed problems with this one
- Matched control firm?
  - A good idea to match on size and book/market (FF factors). Essentially, match on FF factors.
  - If more "factors" are identified in the future, then match on these as well.

Clustering

- What happens when your events are clustered in time?
  - Is this more of a problem for long-run or short-run event studies?
  - What is the problem?
  - See Mitchell and Stafford (1999) for a solution.