ALGORITHMIC FINANCE

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Version 1.0
March 23, 2018

CONTENTS

CHAPTER 4

EVENT STUDY

4.1 Introduction

Event study as a research methodology is about the quantitative analysis of news that may or may not have material effects in the financial markets. A key question addressed in event study is whether or not "good news" will give rise to share price appreciation, "bad news" to share price decline, and "neutral news" to no material price change.

An interesting and certainly significant application of event study is in the courtroom. Mitchell and Netter provide a detailed account of the Securities and Exchange Commission (SEC) applying the event study methodology to establish evidence of insider trading (see Mitchell & Netter (1994)). Moreover, Tabak and Dunbar conclude that event studies are useful in quantifying damages in litigation cases requiring the calculation of lost profits (see Tabak & Dunbar (2001)).

The notions of "good," "bad," and "neutral" require some sort of market expectations. Anecdotal evidence suggests that many company-related announcements are likely to impact the share price. In the event study, each of such announcements is treated as an event. Typically, stock analysts who cover the company will provide updated forecasts before the impending announcement. The consensus in the form of their forecasts' average constitutes the market expectation. When the actual value announced is greater than the consensus, i.e., when it is of upside surprise, the announced news is said to be good news. By the same token, downside surprise is bad news, and when the actual and the consensus coincide, the news is said to be in line with the market expectation. Moreover, if the surprise element of an event is large, its impact will tend to be more salient and the share price may change dramatically after the announcement.

What are the possible types of events that have the potential to bring about an unusual response in the market? In the following, we present a list of 22 event types.

A. Company earnings
B. Manager's guidance or forecast
C. Company revenues from sales
D. Profit warning
E. Launch of new products & services
F. Stock split
G. Change in dividend payout
H. Shares buyback
I. Seasoned shares offering
J. Change in company's key personnel
K. Sale and purchase of company shares by key personnel
L. IPO of a company's subsidiary
M. bankruptcy
N. Merger & acquisition
O. Sales or purchase of a business unit
P. Accounting irregularity
Q. Litigation
R. Stock analysts' upgrade and downgrade
S. Upgrade and downgrade by credit ratings agencies
T. Addition to and deletion from an index membership
U. Investment and divestment by financial institutions
V. Change in regulatory measures

Event types from items A to M originate from the company's insiders. On the other hand, event types from item R to item V are engendered by company's outsiders. Items N to Q may be announced by either the insider or the outsider, or both.

The list of 22 event types is by no mean exhaustive. Moreover, even for events of the same type, it is important to emphasize that the sample of events used for the empirical analysis must be of the same nature. As an example, consider event type 1, company's earnings. To make the event analysis meaningful, sample consisting of positive earnings surprises must be separated from events about negative earnings surprises, as well as from events that have no surprises. Otherwise, the effects arising from positive surprises may annihilate the price impacts of negative surprises, and the events of no surprises may compromise the statistical significance of the test.

The listing is also by no mean non-overlapping. Announcements of company earnings for the quarter just ended tend to occur in conjunction with managers' guidance with regard to the prospect of future earnings. One can argue that the positive price effect is not due so much to the positive earnings surprise. Rather, it may be attributable to the earnings guidance or outlook that beats the analysts' expectation. It is therefore critical to control for other concurrent events when analyzing the effects of positive earnings surprises. For example, in sampling earnings that beat the street, choose only those for which the manager guidance is in line with the market.

4.2 Event Window and Benchmarks

Another crucial ingredient in an event study is the accuracy of the announcement dates. Complications will arise when the announcement dates are not exactly determined. Even so, it is also important to know whether the announcement occurs before the market opens, during the market session, or after the market has closed for trading. If the announcement is after the market has closed, then the following business or trading day will be taken as the event date. In this case, the event date is the trading day immediately after the announcement.

Definition 4.1 The event date is defined as the date of announcement if the announcement is made before the stock market opens, or during the stock market in session before the closing hours. On the other hand, if the announcement is made after the stock market has closed. the event date is then the following trading day. The event date is denoted as day 0. ■

Relative to day the event date, day 0, the event window comprises the pre-announcement window and the post-announcement window. Figure 4.1 is an example of event window, which is ± 10 days surrounding day 0. Of course nothing is sacrosanct about "10 days". Depending on the problem at hand, the half length of the event window can be 2 or 5 days, or longer than 10 days.

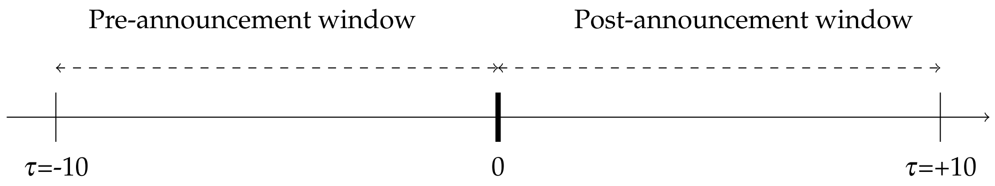


Figure 4.1 Event window

The event window is part of a much larger time frame as shown in Figure 4.2. The period before the event window is referred to as the estimation period. Observations in this time period form the basis for establishing a comparison benchmark with which to ascertain whether the returns in the event window are abnormal. The benchmark is of critical importance in any event study. Without the benchmark, it is impossible to claim abnormality on the event day. For example, suppose at day 0, the stock price is 2% higher than the stock price at day -1. Is the 2% increment normal or abnormal? In the absence of a benchmark, one can always argue that the increment is due to its usual co-movement with the market, or with the industry group the stock belongs to.

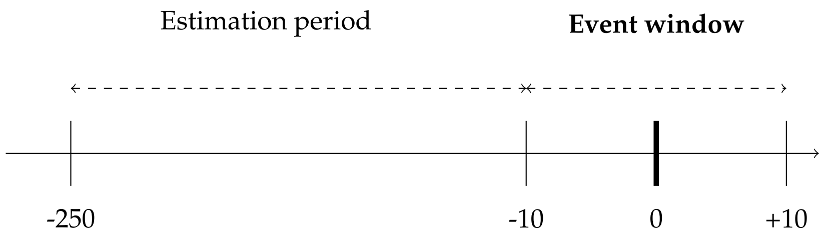


Figure 4.2 Time frame of event study

4.2.1 Constant Mean Model

Suggested only as an example, the length of ± 250 from day 0 for the estimation and post-event periods in Figure 4.2 is not a number cast in stone. Depending on the benchmark used, the post-event period, which is the time period after the event window, may not be necessary. But for the constant mean model, it may be necessary.

Suppose the mean return for stock i is denoted by μ_i. The constant mean model is simply

$$r_{it} = \mu_i + \varepsilon_{it} \,,$$

where r_{it} is the daily return on security i and ε_{it} is the disturbance with mean 0 and constant variance $\sigma^2_{\varepsilon_i}$. For this benchmark, the mean of r_{it} is estimated using the observations in the estimation period. At times, the post-event period is included to estimate μ_i.

The constant mean model is especially useful when you want to evaluate the stock market response to a macro-economic announcement. A well-known example is the monetary policy announcement by the Federal Reserve. Specifically, the Federal Open Market Committee (FOMC) usually holds eight regularly scheduled meetings each year. Many economists and analysts in the financial industry will attempt to forecast whether FOMC will adjust the target federal funds rate, and going forward, hints about FOMC stance. This macro-economic news impacts almost all markets: bond, foreign exchange, stock, and to some degree, commodity markets. Since there is no such thing as a "market benchmark" for a stock market index such as the S&P 500 index, the constant mean is currently the only model for the FOMC announcements.

4.2.2 No Estimation Model

The simplest benchmark is to take a well accepted stock market index such as the S&P 500 index as the benchmark. In other words, the return r_{mt} on the market is the benchmark.

4.2.3 Market Model

The market model is motivated by the empirical observation that the return of an asset tends to co-move with the equity index representative of the overall market behavior. It is an empirical model and requires no assumptions on market equilibrium, rational behaviors on the part of "agents" in the economy, market efficiency, and so on. For an asset i's return r_{it} at time t, it is contemporaneously dependent on the explanatory variable, r_{mt}, the return on the market index.

$$r_{it} = \alpha_i + \beta_i r_{mt} + \varepsilon_{it}. \tag{4.1}$$

Like any other classical linear regression model, the market model assumes that the residual ε_{it} has zero mean and homoskedastic variance of $\sigma^2_{\varepsilon_i}$. The regression coefficients α_i and β_i, along with $\sigma^2_{\varepsilon_i}$, characterize the asset i's return in the market model. The other two assumptions of the market model are $\mathbb{C}(e_{it}, e_{is}) = 0$ for $t \neq s$, and $\mathbb{C}(e_{it}, r_{mt}) = 0$ for all t in the estimation period.

4.2.4 Capital Asset Pricing Model

From the standpoint of regression specification, the capital asset pricing model is the inclusion of risk-free rate f_{ft} to the market model:

$$r_{it} - r_{ft} = a_i + b_i(r_{mt} - r_{ft}) + e_{it}.$$

But at the daily level, r_{ft} is a small value. For example if the risk-free rate is 1% per annum, then the daily risk-free rate is only 2.73×10^{-5} (= 0.01/(365)).

4.3 Abnormal Returns

As discussed earlier, to remove the effect of dependence on market movement, we need an appropriate return on the benchmark, which is denoted by r_{bt}.

Definition 4.2 Given the return on benchmark r_{bt}, the abnormal return of an event i in the event window is defined as

$$\text{AR}_{i\tau} := r_{it} - r_{bt}.$$

■

MacKinlay suggest that ordinary least squares (OLS) is a consistent estimation procedure for the market model coefficients under general conditions (see MacKinlay (1997)). We denote the OLS estimates by $\widehat{\alpha}_i$, $\widehat{\beta}_i$, and $\widehat{\sigma}^2_{\varepsilon_i}$, respectively.

Definition 4.3 Using the market model as the benchmark, the abnormal return denoted by $\text{AR}_{i\tau}$ of an event involving firm i is defined as

$$\begin{aligned} \text{AR}_{i\tau} &:= r_{i\tau} - \widehat{r}_{i\tau} \\ &= r_{i\tau} - \widehat{\alpha}_i - \widehat{\beta}_i r_{m\tau}. \end{aligned}$$

In other words, given the observation of the market return $r_{m\tau}$, the abnormal return is the difference between the actual return $r_{i\tau}$ and the usual or normal return $\widehat{r}_{i\tau}$ predicted by the market model. ■

Proposition 4.4 In the event window where day number is indexed by τ, the expected value of $\text{AR}_{i\tau}$ conditional on the knowledge of $r_{m\tau}$ is zero, i.e.,

$$\mathbb{E}\left(\text{AR}_{i\tau} \middle| r_{m\tau}\right) = 0. \tag{4.2}$$

■

Proof: From the market model (4.1), we have $r_{i\tau} = \alpha_i + \beta_i r_{m\tau} + \varepsilon_{i\tau}$. By assumption, $\mathbb{E}\left(\varepsilon_{it} \middle| r_{m\tau}\right) = \mathbb{E}\left(\varepsilon_{it}\right) = 0$, since the explanatory variable does not co-vary with the residual and hence provide no information on the expected value of ε_{it}. As OLS estimates $\widehat{\alpha}_i$ and $\widehat{\beta}_i$ are unbiased, their expected values are the true values, α and β, respectively. It follows that

$$\begin{aligned} \mathbb{E}\left(\text{AR}_{i\tau} \middle| r_{m\tau}\right) &= \mathbb{E}\left(\alpha_i + \beta_i r_{m\tau} + \varepsilon_{i\tau} - \widehat{\alpha}_i - \widehat{\beta}_i r_{m\tau} \middle| r_{m\tau}\right) \\ &= \alpha_i + \beta_i r_{m\tau} + \mathbb{E}\left(\varepsilon_{it} \middle| r_{m\tau}\right) - \mathbb{E}\left(\widehat{\alpha}_i \middle| r_{m\tau}\right) - r_{m\tau}\mathbb{E}\left(\widehat{\beta}_i \middle| r_{m\tau}\right) \\ &= 0 \end{aligned}$$

■

Suppose the average market return $\overline{r}_m$ is estimated with the observations in the estimation period, i.e.,

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

Proposition 4.5 The variance of $\mathrm{AR}_{i\tau}$ conditional on the knowledge of $r_{m\tau}$ is

$$\mathbb{V}(\mathrm{AR}_{i\tau}|r_{m\tau}) = \sigma^2_{\varepsilon_i}\left(1+\frac{1}{L}+\frac{(r_{m\tau}-\overline{r}_m)^2}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2}\right), \tag{4.3}$$

for each day τ in the event window. ■

Proof: Following Lim (2011), the conditional variance of $\mathrm{AR}_{i\tau}$ is computed as follows:

$$\begin{aligned}\mathbb{V}(\mathrm{AR}_{i\tau}|r_{m\tau}) &= \mathbb{V}(r_{i\tau}-\widehat{\alpha}_i-\widehat{\beta}_i r_{m\tau}|r_{m\tau})\\ &= \mathbb{V}(r_{i\tau}|r_{m\tau})+\mathbb{V}(\hat{\alpha}_i|r_{m\tau})+r^2_{m\tau}\mathbb{V}(\hat{\beta}_i|r_{m\tau})\\ &\quad +2r_{m\tau}\mathbb{C}(\hat{\alpha}_i,\hat{\beta}_i|r_{m\tau})-2\mathbb{C}(r_{i\tau},\hat{\alpha}_i|r_{m\tau})-2r_{m\tau}\mathbb{C}(r_{i\tau},\hat{\beta}_i|r_{m\tau}).\end{aligned}$$

Given the market return $r_{m\tau}$, the conditional variance of $r_{i\tau}$ under the market model is $\mathbb{V}(r_{i\tau}|r_{m\tau}) = \sigma^2_{\varepsilon_i}$. The two covariances $\mathbb{C}(r_{i\tau},\widehat{\alpha}_i|r_{m\tau})$ and $\mathbb{C}(r_{i\tau},\widehat{\beta}_i|r_{m\tau})$ are zero because in these conditional covariances, the contributing element is the noise $\varepsilon_{i\tau}$ for $r_{i\tau}$. The noise $\varepsilon_{i\tau}$ and $\widehat{\alpha}_i$ obviously do not co-vary since noise by definition does not co-vary any other random variable. Likewise, $\mathbb{C}(r_{i\tau},\widehat{\beta}_i|r_{m\tau}) = 0$.

Consequently, we have

$$\begin{aligned}\mathbb{V}(\mathrm{AR}_{i\tau}|r_{m\tau}) &= \sigma^2_{\varepsilon_i}+\sigma^2_{\varepsilon_i}\left(\frac{1}{L}+\frac{\overline{r}^2_m}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2}\right)+\sigma^2_{\varepsilon_i}\frac{r^2_{m\tau}}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2}\\ &\quad -2\sigma^2_{\varepsilon_i}\frac{r_{m\tau}\overline{r}_m}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2}\\ &= \sigma^2_{\varepsilon_i}\left(1+\frac{1}{L}+\frac{(r_{m\tau}-\overline{r}_m)^2}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2}\right).\end{aligned}$$

■

With these two propositions in place, the distribution of the abnormal return for each τ in the event window is given by

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

It is noteworthy that the covariance is dependent on $r_{m\tau}$, and thus $\mathbb{V}(\mathrm{AR}_{i\tau}|r_{m\tau})$ is different for different τ in the event window.

The null hypothesis of the event study is $H_0 : \mathrm{AR}_{i\tau} = 0$. To perform the statistical test, the variance of the OLS residuals is first estimated as

$$\widehat{\sigma}^2_{\varepsilon_i} = \frac{1}{L-2}\sum_{t=-L-10}^{-11}\widehat{\varepsilon}^2_{it}.$$

With finite L, the standard error (SE) is

$$\mathrm{SE}(\mathrm{AR}_{i\tau}) = \widehat{\sigma}_{\varepsilon_i}\sqrt{1+\frac{1}{L}+\frac{(r_{m\tau}-\overline{r}_m)^2}{\sum_{t=-L-10}^{-11}(r_{mt}-\overline{r}_m)^2}},$$

and the t statistic for the null hypothesis of zero abnormal return at time τ is

$$\frac{\mathrm{AR}_{i\tau}}{\mathrm{SE}(\mathrm{AR}_{i\tau})} \overset{d}{\sim} t_{L-2}.$$

Note that the standard error is different for different τ.

4.4 Cumulative Abnormal Returns

To draw overall inferences for the event, the abnormal return is aggregated through the event window. The resulting quantity is called the the cumulative abnormal return (CAR).

Definition 4.6 For an event i, having computed the abnormal returns for each τ in the event window of half-size W, the cumulative abnormal return is defined as

$$\mathrm{CAR}_i(\tau_k) := \sum_{\tau=-W}^{\tau_k} \mathrm{AR}_{i\tau}, \tag{4.4}$$

with τ_k ranging from $-W$ to W. ■

EXAMPLE 4.1

Suppose $W=10$. The first cumulative abnormal return $\mathrm{CAR}_i(-10)$ is simply $\mathrm{AR}_{i,-10}$. The last CAR is $\mathrm{CAR}_i(10)$, which is the sum of all $\mathrm{AR}_{i\tau}$ from $\tau=-10$ to $\tau=10$. In general,

$$\mathrm{CAR}_i(\tau_k) = \mathrm{AR}_{i,-10}+\mathrm{AR}_{i,-9}+\cdots+\mathrm{AR}_{i,\tau_k-1}+\mathrm{AR}_{i,\tau_k}.$$

■

The expectation of $\mathrm{CAR}_i(\tau_k)$ conditional on k market returns $\{r_{m\tau}\}_{\tau=-10}^{\tau_k}$ is zero, since

$$\mathbb{E}\Big(\mathrm{CAR}_i(\tau_k)\big|\{r_{m\tau}\}_{\tau=-10}^{\tau_k}\Big) = \mathbb{E}\left(\sum_{\tau=-W}^{\tau_k}\mathrm{AR}_{i\tau}\right) = \sum_{\tau=-W}^{\tau_k}\mathbb{E}(\mathrm{AR}_{i\tau}) = 0.$$

Next, assuming that the abnormal returns $\mathrm{AR}_{i\tau}$ are independent over different event window time τ, the conditional variance of $\mathrm{CAR}_i(\tau_k)$ is simply the sum of the conditional variance of each abnormal return, i.e.,

$$\mathbb{V}\Big(\mathrm{CAR}_i(\tau_k)\big|\{r_{m\tau}\}_{\tau=-W}^{\tau_k}\Big) = \sum_{\tau=-W}^{\tau_k}\mathbb{V}(\mathrm{AR}_{i\tau}|r_{m\tau}). \tag{4.5}$$

As in the case of $\mathrm{AR}_{i\tau}$, for the cumulative abnormal return, the null hypothesis is H_0 : $\mathrm{CAR}_i(\tau_k) = 0$ for $\tau_k = -W$ to $\tau_k = W$. When L is large, the test statistic is approximately given by

$$\frac{\mathrm{CAR}_i(\tau_k)}{\sqrt{\mathbb{V}\left(\mathrm{CAR}_i(\tau_k) \middle| \{r_{m\tau}\}_{\tau=-10}^{\tau_k}\right)}} \stackrel{d}{\sim} N(0,1).$$

Proposition 4.7 When log returns are used instead of the simple returns in the event study, $\mathrm{CAR}_i(\tau_k)$ for $\tau_k = -W, -W+1, \ldots, W-1, W$, may be interpreted as the market adjusted or normalized price. ■

Proof: Due to the telescoping property, a sum of log returns is equal to the difference between the last and the first log prices. It follows that, with $W = 10$ without loss of generality,

$$\begin{aligned}
\mathrm{CAR}_i(\tau_k) &= \sum_{\tau=-10}^{\tau_k} \left(r_{i\tau} - \widehat{\alpha}_i - \widehat{\beta}_i r_{m\tau} \right) = \sum_{\tau=-10}^{\tau_k} r_{i\tau} - k\widehat{\alpha}_i - \widehat{\beta}_i \sum_{\tau=-10}^{\tau_k} r_{m\tau} \\
&= \ln(P_{i,\tau_k}) - \ln(P_{i,-11}) - \widehat{\beta}_i \left(\ln(P_{m,\tau_k}) - \ln(P_{m,-11}) \right) - k\widehat{\alpha}_i \\
&= \ln(P_{i,\tau_k}) - \widehat{\beta}_i \ln(P_{m,\tau_k}) - c \\
&= \ln(P_{i,\tau_k}) - \ln(\widehat{P}_{m,\tau_k}) - c,
\end{aligned}$$

where c is the sum of three constant terms

$$c := k\widehat{\alpha} + \ln\left(P_{i,-11}\right) - \widehat{\beta} \ln\left(P_{m,-11}\right), \tag{4.6}$$

and the "market price" $\widehat{P}_{m,\tau_k}$ is

$$\widehat{P}_{m,\tau_k} := P_{m,\tau_k}^{\widehat{\beta}}.$$

Therefore, up to a constant c, $\mathrm{CAR}_i(\tau_k)$ is interpretable as the log price at time τ_k normalized by the "market price", i.e.,

$$\mathrm{CAR}_i(\tau_k) = \ln\left(\frac{P_{i,\tau_k}}{\widehat{P}_{m,\tau_k}}\right) - c. \tag{4.7}$$

■

Moreover, Proposition 4.7 allows you to profit from your research on the element of surprise in a particular event. Suppose you think that $\mathrm{CAR}_i(0)$ is significantly positive on event day 0. You can take a long position in the stock and take a short position in an exchange traded fund (ETF) on S&P 500 index on day -11 or more generally $-(W+1)$. In this case, c in Equation (4.6) can be interpreted as the cost of this long-short strategy. To be more accurate, it is better to use the ETF in place of the S&P 500 index as the market portfolio in the estimation of α_i and β_i.

In this context, $\widehat{\beta}$ acts as the "hedge ratio" for the log prices, since our long-short position is

$$\ln(P_{i\tau}) - \widehat{\beta}\ln(P_{m,\tau}).$$

Moreover, Equation (4.7) *is* the P&L if you hold your long-short strategy till τ_k. Your P&L is thus $\text{CAR}_i(0)$ on event date.

4.5 Case Study: AIG in Crisis

To demonstrate how an event study is applied, this section provides a case study of a nwes release about AIG during the 2008 financial crisis. A point of interest is to examine whether or not there is any form of information leakage prior to the news release. By information leakage, we mean that the cumulative abnormal return is statistically significant for at least one day in the pre-announcement window, i.e., when $\tau < 0$. The economic significance of the leakage can be assessed from the corresponding abnormal return in the pre-announcement period.

Another aspect concerns the impact on AIG's stock price after the news release. The cumulative abnormal return may shed light on whether the event has a temporary or permanent effect on the stock price. The effect is said to be temporary if CAR reverts back to the pre-announcement level. Otherwise, the impact is said to be permanent.

4.5.1 Background of the Case Study

AIG, or American International Group, is an international insurance company that has an extensive web-like network covering more than 130 countries and jurisdictions. In the United States, companies of AIG provide life insurance and retirement services. Incorporated in 1967, its roots, however, can be traced to an insurance company started by Starr in Shanghai, China, in 1919. Since then, AIG enjoyed glorious years of expansion after expansion.

In 1987, AIG set up AIG Financial Products (AIGFP) to focus on trading complex derivatives. About 10 years later, this money-making subsidiary of AIG started selling insurance protections against debt defaults. AIGFP was running a profitable business when the default risk was low. But in 2007, with the housing market collapsing and sub-prime assets plummeting in value, AIG was demanded by its counterparties to post more collateral. As the mortgage defaults kept rising, AIGFP lost more than \$10 billion in 2007 and another \$14.7 billion in the first six months of 2008.

By September 2008, ratings agencies had made suggestions about their plans to downgrade AIG's rating yet again. Further downgrade would trigger more collateral calls, which AIG knew it could not cover. Desperate negotiations to keep the company afloat ensured. With no suitable white knight in sight, AIG had to ask the U.S. federal government to bail it out. On September 14, 2008, 9:57 pm, the New York Times' DealBook posted a nerve-racking news with the following headline:

A.I.G. Seeks $40 Billion in Fed Aid to Survive

4.5.2 Event Analysis and Results

Since the breaking news appeared on September 14, 2008, which was a Sunday, the event date for this analysis therefore is September 15. On that fateful Monday, AIG stock fell $7.38, or 61% (equivalent to 94.16% log return), to $4.76. The S&P 500 index declined 59 points, or 4.71%, to 1,192.70, its biggest drop since 9/11 and the first time it closed below 1,200 in three years.

To perform the event analysis, the daily closing prices of AIG and that of an ETF on S&P 500's index with the ticker symobl SPY are obtained from **Global Financial Data**. The length L of the estimation period is set as 240. OLS regression on the market model produces

$$r_{it} = -0.003492 + 2.073427 \times r_{mt}.$$

The two coefficient estimates are statistically significant at the 5% significance level.

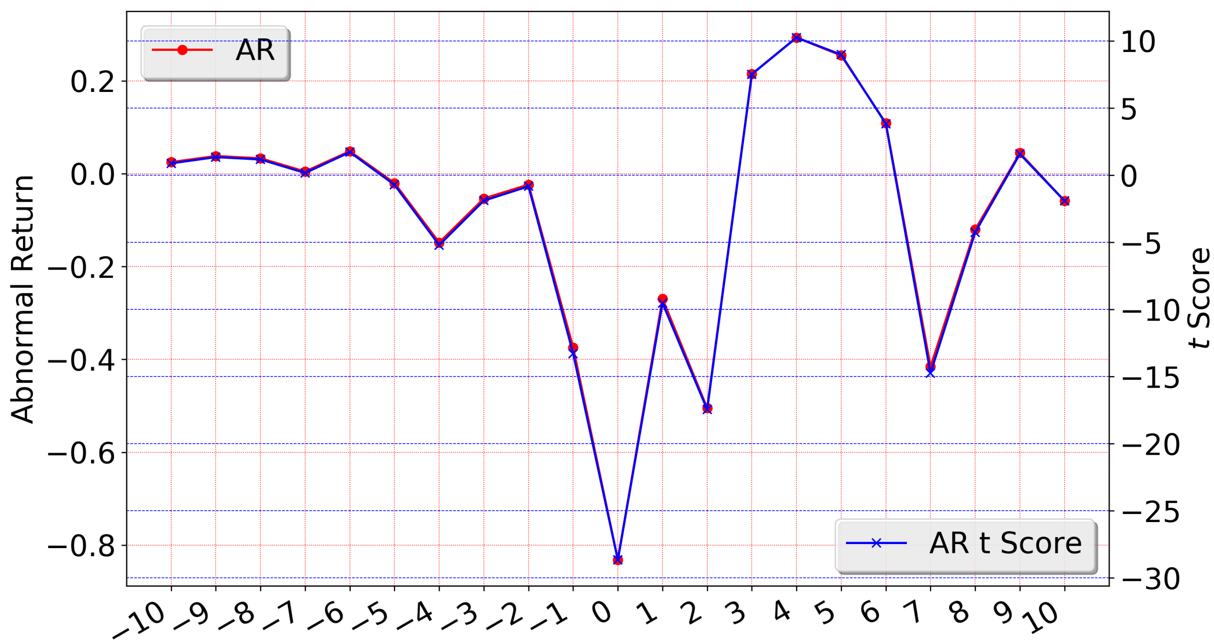
The $\text{AR}_{i\tau}$, $\text{CAR}_i(\tau_k)$, and their t statistics are computed using the formulas in Sections 4.3 and 4.4. The results are presented in Figure 4.3 for the abnormal returns. For cumulative abnormal returns and their statistics, they are plotted in Figure 4.4. Notably, $\text{CAR}_i(\tau_k)$ looks like a price series.

The statistical evidence suggests that, as anticipated, there was a material impact of the news release on AIG's stock price on the event date. The t statistic for $\text{CAR}_i(0)$ shows that it is highly significant, implying that the cumulative abnormal return is non-zero on the event day.

The negative abnormal return on September 15 might have been even more negative. AIG's stock pared some of its losses after news came, confirming that AIG was allowed by the State of New York to access $20 billion of assets held by AIG's subsidiaries to stay in business.

Subsequently, a report hit late Monday that the Federal Reserve had asked Goldman Sachs and JPMorgan Chase, two key survivors of the mortgage-bond shakeout, for up to $75 billion in credit to extend to the giant insurer. AIG was such an integral part of the financial system that systemic risk was assessed to be clearly present. If AIG were to thread the demise path of Lehman Brothers, all insurance policy holders on the main street would probably lose confidence in the entire financial system. Even the outgoing Bush Administration could not afford to displease the main street, certainly not when the U.S. election was just around the corner. The bail-out deal, effectively a move toward nationalization, or "conservatorship," was structured so that AIG had an incentive to clean up the mess as quickly as possible.

Figure 4.3 Abnormal Returns and Their *t* Statistics.



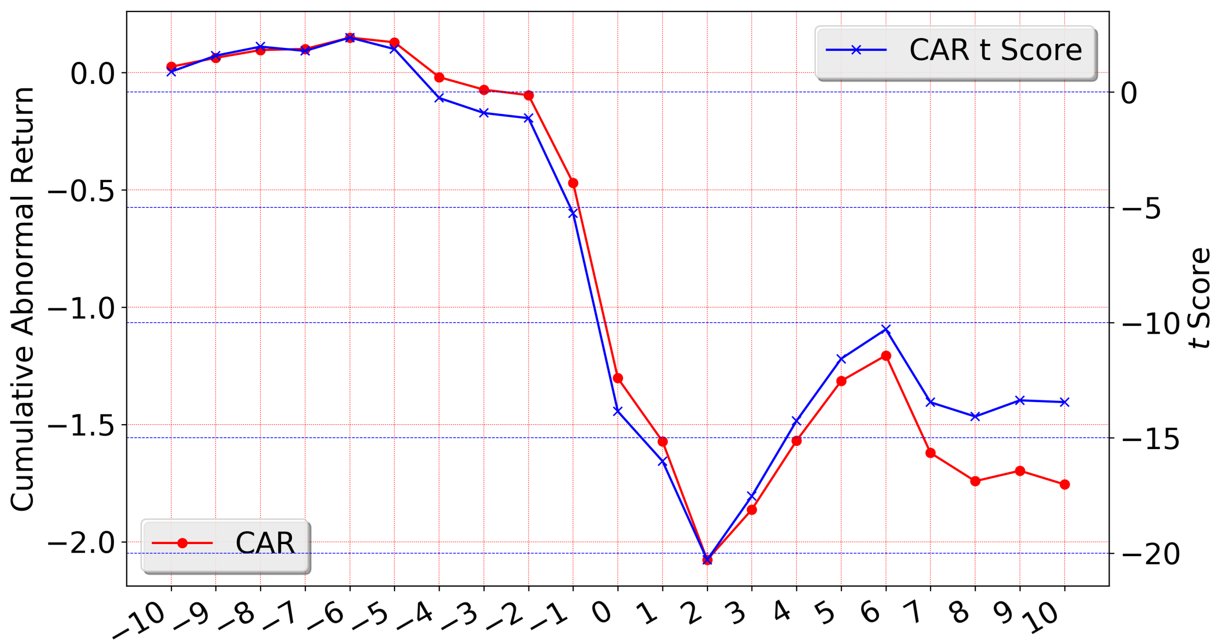
In the statistical test, extremely noteworthy is a day before the event day. The t statistic for $\text{AR}_{i,-1}$ is -13.28 and for $\text{CAR}_i(-1)$ is -5.26. These statistics lead us to the inference that the null hypothesis must be rejected. This finding implies that there might either be an information leakage, or some statements about AIG were released before or during the market hours on September 12 (Friday).

A news in the Wall Street Journal, "AIG Scrambles to Raise Cash, Talks to Fed," which appeared on September 14, reported that

> But its shares fell 31% on Friday alone. Late that day, Standard & Poor's warned that it could cut AIG's credit rating by one to three notches, citing concerns that AIG would have difficulty raising capital. Such a step would make it more expensive for AIG to borrow and further undermine investor confidence in the company.

From this news, it seems likely that S&P's threat of downgrade was issued after the market had closed on September 12, 2008 (Friday). If that is the case, then the plunge of 31% on September 12 was not due to any news announcement before or during

Figure 4.4 Cumulative Abnormal Returns and Their t Statistics.



the trading hours. If there was no major news concerning AIG from 4 pm, September 11 to 9:30 am September 12, then leakage of information about either S&P's downgrade plan or AIG seeking a bail-out from the Federal Reserve might have occurred (see also a New York Times report entitled "A.I.G. Allowed to Borrow Money From Subsidiaries," which was published on September 15).

Finally, we note that the bad news about AIG seems to have a permanent effect. The market-adjusted price appears to remain depressed at about -1.75 and does not return to 0, as shown in the CAR chart in Figure 4.4.

4.5.3 Trading Strategy

Suppose you take a short position in AIG and a long position in SPY with the hedge ratio $\widehat{\beta} = 2.073427 \approx 2$ on day -11. The cash flow is

$$\ln(P_{i,-11}) - 2 \times \ln(P_{m,-11}).$$

On event date, you liquidate your position, and the cash flow is

$$-\ln(P_{i,0}) + 2 \times \ln(P_{m,0}).$$

It follows that your P&L in percent is

$$2 \times \ln\left(P_{m,0}/P_{m,-11}\right) - \ln\left(P_{i,0}/P_{i,-11}\right).$$

AIG's prices per share are \$21.51 and \$4.76 for days -11 and 0, respectively That is, $P_{i,-11} = \$21.51$ and $P_{i,0} = \$4.76$. The corresponding prices of SPY are $P_{m,-11} = \$130.19$ and $P_{m,0} = \$120.09$. Thus, the P&L computed is

$$2 \times \ln(120.09/130.19) - \ln(4.76/21.51) = 1.347 = 134.7\%.$$

This value of 1.347 is compatible with the value of $\left|\mathrm{CAR}_i(0)\right| = 1.302$ computed using Equation (4.4) or (4.7). The difference comes from $k\widehat{\alpha}$ as in Equation (4.6), and to a lesser extent, the rounding down of $\widehat{\beta}$. In our illustration, $k = 11$ and thus $k\widehat{\alpha} = 11 \times (-0.003492) = -3.84\%$.

4.6 Average Abnormal Return

In the case study of AIG in crisis, there is only one event. For regular and scheduled earnings announcements, however, there are many events. As mentioned previously, it is important to control for company guidance if one were to ascertain whether positive earnings surprises will or will not have a positive price effect, for announcements of earnings and guidance tend to occur on the same date.

Roughly speaking, event type 1 in Section 4.1 has three possible outcomes: upside earnings surprise, in line, and downside earnings surprise. Similarly, event type 2 can be categorized into three possible outcomes: upside guidance surprise, in line, and downside guidance surprise. Altogether there are 9 possible outcomes and they are denoted by the symbols u_e, n_e, and d_e for upside, no, and downside earnings surprises, respectively. The same set of 3 outcomes for guidance comprises u_g, n_g, and d_g. The 9 combinations along with the numbers of earnings and guidance surprises from brieif.com are tabulated in Table 4.1. Announcements of these events were made from 2001 through 2012.

We find that earnings surprises tend to be on the upside. In total, 18,568 earnings beat the street, compared to 3,844 in line with the market, and 5,111 earnings that are disappointing. For guidance on future earnings, it appears that managers and analysts tend to agree more; 12,874 events are in line, compared to 6,634 events where managers are more optimistic than the analysts, and 8,015 events for which managers are less optimistic. Taken together, company managers tend to report earnings per share that are higher than analysts' consensus, and their guidance for future earnings usually matches analysts' consensus.

Earnings announcements at time T pertain to the financial accounts for the past quarter that has just ended, whereas guidance is typically for the current quarter for which the announcement date T resides. Before the announcement, company managers know the latest analysts' forecast consensus for the immediate past quarter,

Earnings \ Guidance	u_g	i_g	d_g	Total
u_e	u_e, u_g	u_e, i_g	u_e, d_g	
	5,632	9,423	3,513	18,568
i_e	i_e, u_g	i_e, i_g	i_e, d_g	
	468	1,161	2,215	3,844
d_e	d_e, u_g	d_e, i_g	d_e, d_g	
	534	2,290	2,287	5,111
Total	6,634	12,874	8,015	27,523

Table 4.1 Combinations of earnings and guidance surprises, along with the numbers of surprises from 2001 through 2012 (data source: **briefing.com**) .

and also their consensus for the current quarter, for all these forecasts are either in the public domain or are made available by financial information service providers. Given these statistics, managers are somehow motivated to beat the market, and also to go along with the market expectation in their guidance.

Consider the combination (u_e, u_g), i.e., upside earnings and guidance surprises, which has $M = 5,632$ events in our sample. The average abnormal return (AAR) across these M events is

$$\mathrm{AAR}_\tau = \frac{1}{M}\sum_{i=1}^{M}\mathrm{AR}_{i\tau}, \qquad \text{for } \tau = -10, -9, \ldots, 9, 10.$$

Observe that there is no subscript i for AAR_τ because it is the cross sectional average of all stock-events in the sample.

Suppose the covariance of $\mathrm{AR}_{i\tau}$ and $\mathrm{AR}_{j\tau}$ is zero for a given τ and for all $i \neq j$. This reasonable assumption implies that company i's earnings and guidance surprises and those of company j in principle have no association over different announcement dates on the calendar. Under this assumption, the conditional variance therefore is

$$\mathbb{V}\left(\mathrm{AAR}_\tau \middle| r_{m\tau}\right) = \frac{1}{M^2}\sum_{i=1}^{M}\mathbb{V}\left(\mathrm{AR}_{i\tau} \middle| r_{m\tau}\right).$$

Each of the conditional variance in the summation is computed according to Equation (4.3). Consequently, the test statistic of the null hypothesis $H_0 : \mathrm{AAR}_\tau = 0$ for a given τ is, assuming large estimation length L, is given by

$$\frac{\mathrm{AAR}_\tau}{\sqrt{\mathbb{V}\left(\mathrm{AAR}_\tau \middle| r_{m\tau}\right)}} \overset{d}{\sim} N(0,1).$$

4.7 Cumulative Average Abnormal Return

Definition 4.8 The cumulative average abnormal return is defined as, for a given τ_k,

$$\mathrm{CAAR}(\tau_k) = \frac{1}{M}\sum_{i=1}^{M}\mathrm{CAR}_i(\tau_k).$$

This is a cross-sectional average of all $\mathrm{CAR}_i(\tau_k)$, where $i = 1, 2, \ldots, M$. The event window time τ_k ranges from $-W$ to W. ■

Proposition 4.9 For each τ_k, suppose the cumulative abnormal returns are uncorrelated across event i. The conditional variance of $\mathrm{CAAR}(\tau_k)$ is then simply the sum of the conditional variance of each cumulative abnormal return, i.e.,

$$\begin{aligned}\mathbb{V}\left(\mathrm{CAAR}(\tau_k)\middle|\{r_{m\tau}\}_{\tau=-W}^{\tau_k}\right) &= \frac{1}{M^2}\sum_{i=1}^{M}\mathbb{V}\left(\mathrm{CAR}_i(\tau_k)\middle|\{r_{m\tau}\}_{\tau=-W}^{\tau_k}\right)\\ &= \sum_{\tau=-W}^{\tau_k}\mathbb{V}\left(\mathrm{AAR}_\tau\middle|r_{m\tau}\right).\end{aligned}$$

■

Proof: The key assumption is that event i and event j do not have association whatsoever. Under this assumption, summation and variance operator are interchangeable, i.e.,

$$\frac{1}{M^2}\sum_{i=1}^{M}\mathbb{V}(X) = \mathbb{V}\left(\frac{1}{M}\sum_{i=1}^{M}X\right).$$

Therefore,

$$\begin{aligned}\frac{1}{M^2}\sum_{i=1}^{M}\mathbb{V}\left(\mathrm{CAR}_i(\tau_k)\middle|\{r_{m\tau}\}_{\tau=-W}^{\tau_k}\right) &= \mathbb{V}\left(\frac{1}{M}\sum_{i=1}^{M}\mathrm{CAR}_i(\tau_k)\middle|\{r_{m\tau}\}_{\tau=-W}^{\tau_k}\right)\\ &= \mathbb{V}\left(\frac{1}{M}\sum_{i=1}^{M}\sum_{\tau=-W}^{\tau_k}\mathrm{AR}_{i\tau}\middle|\{r_{m\tau}\}_{\tau=-W}^{\tau_k}\right)\\ &= \mathbb{V}\left(\sum_{\tau=-W}^{\tau_k}\frac{1}{M}\sum_{i=1}^{M}\mathrm{AR}_{i\tau}\middle|\{r_{m\tau}\}_{\tau=-W}^{\tau_k}\right)\\ &= \mathbb{V}\left(\sum_{\tau=-W}^{\tau_k}\mathrm{AAR}_\tau\middle|\{r_{m\tau}\}_{\tau=-W}^{\tau_k}\right)\end{aligned}$$

The proof is complete when we interchange the variance operator and the summation over τ. ■

As anticipated, for cumulative abnormal return, the null hypothesis is $H_0 : \mathrm{CAAR}(\tau_k) = 0$ for each of τ_k ranging from $\tau_k = -W$ to $\tau_k = W$. When L is large, the test statistic is approximately given by

$$\frac{\text{CAAR}(\tau_k)}{\sqrt{\mathbb{V}\Big(\text{CAAR}_i(\tau_k)\Big|\{r_{m\tau}\}_{\tau=-W}^{\tau_k}\Big)}} \overset{d}{\sim} N(0,1).$$

4.8 Summary

EXERCISES

4.1 With the market model being employed as the benchmark, and the length of the estimation period being 91, the residual sum of squares is 0.5 from the simple linear regression. Coincidently, the market return $r_{m,10}$ equals its sample average. What is the standard error for $AR_{i,10}$ (accurate to 2 decimal places)?

4.2 When the length L of the estimation period is large, what is a good approximation of the variance of $\text{AR}_{i\tau}$ in Equation (4.3)?

4.3 Suppose $\text{AR}_{i\tau} \overset{d}{\sim} N(0, 0.02)$ for all τ. What is the distribution of the cumulative abnormal return $\text{CAR}_i(10, -10) = \sum_{\tau=-10}^{10} \text{AR}_{i\tau}$?

4.4 Consider $M = 5$ events of the same type. Suppose the sum of the variances for these events is 0.06 for a particular day τ in the event window. What is the distribution of AAR_τ?

4.5 Write a summary of at least 153 words on what you have really learned from this chapter on the subject of event study.

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