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Misspecification in event studies☆

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ABSTRACT

We examine the statistical error and efficiency associated with two commonly used event-study techniques when applied to samples of various sizes. Previous research has established that the frequently used Patell (1976) test is not well specified when the event itself creates additional return variance. We find that even under ideal conditions when the event creates no additional variance, the Patell test rejects a true null hypothesis substantially more often than the stated significance level. In contrast, the alternate test of Boehmer et al. (1991) performs well in samples of all sizes and under all conditions we consider.

1. Introduction

Since the introduction of event-study methods in accounting (Ball and Brown, 1968) and financial research (Fama et al., 1969), they have been the predominant method of determining whether an event is associated with a change in firm value. Typically, a researcher collects a sample of firms experiencing the event and tests whether their returns on the event day are significantly different from what would be expected absent the event.

The required statistical tests usually rely on the Central Limit Theorem (CLT),[1] of which there are several versions. The most common version (Feller, 1968, for example) asserts that if $\{X_i\}_{i=1}^{N}$ is a random sample from a population with finite mean and variance, then the sampling distribution of the mean of $\{X_i\}$ approaches a normal distribution as $N \to \infty$. The theorem is silent concerning the rate of convergence, although it is known that convergence is faster when the skewness and kurtosis of the underlying distribution are near their values for a normal distribution.

Daily stock returns, however, are known to be both skewed and have fat tails (e.g., Mandelbrot (1963) and Fama (1965)), and this remains true of abnormal returns calculated relative to a benchmark return (Brown and Warner, 1985). Indeed, Mandelbrot and Fama speculated that the population of stock returns might not even have a finite variance, although subsequent research favored the conjecture that stock returns are drawn from a finite mixture of normal distributions (e.g., Campbell et al. (1997),

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[1] One method that does not rely on the CLT is Corrado's (1989) non-parametric test.

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pp. 18–19; Harris (1986); or Kon (1984)). A population variance that is not finite would imply we cannot rely on the CLT at all, but even the assumption that daily stock returns are drawn from a mixture distribution with fat tails means that we cannot assume "small" samples necessarily have the properties required to apply standard parametric tests. The size required for a sample of daily stock returns to be sufficiently large for an event-study test to be well specified is primarily an empirical matter. Brown and Warner (1985) and Boehmer et al. (1991) examined this issue, but both used only 250 simulated portfolios of size 50 events each. The use of only 250 simulated portfolios leads to confidence intervals that are quite wide, thus making it difficult to detect misspecification of the test. For example, at a significance level of $\alpha = 5\%$ and when the number of simulations is only 250, the 95% confidence interval suggested by the $\sqrt{npq}$ binomial approximation of standard deviation is $0.05 \pm \frac{1.96\sqrt{250(0.05)(0.95)}}{250}$, or (3.3%, 7.7%). Given that the minimum increment to the rejection frequency is $\frac{1}{250} = 0.4\%$, a method would have to reject a true null 60% more often than it should to conclude that it is misspecified. The small number of simulations was a constraint imposed by the computing power of that era, but this is not a significant limitation today.

We reexamine this issue using 10,000 simulated event portfolios. This provides tighter confidence intervals and thus more powerful tests for misspecification. We find that even if the event does not alter the dispersion of standardized abnormal returns (abnormal return normalized by the standard deviation of the estimation period residuals), the default method in Eventus is misspecified for samples from 100 to as large as 5000 firms. Like Boehmer et al. (1991) and Harrington and Shrider (2007), we find this misspecification is markedly larger if the event causes an increase in variance, which Harrington and Shrider find it necessarily does. The method of Boehmer et al. (1991), hereafter referred to as the BMP test, is based on a cross-sectional test of standardized abnormal returns and is well specified for all portfolio sizes we considered, both in the absence or presence of event-induced variance. Furthermore, while the default test statistic in Eventus is the Patell test, the BMP test statistic can just as easily be chosen by selecting the STDCSECT option. For researchers who access Eventus through Wharton Research Data Services, step 5 of the query form provides the ability to select different test statistics, including both Patell and BMP.[2]

Finally, because the large number of simulations might lead us to conclude that a test is statistically misspecified even though it produces good practical results, we apply Bayes' Theorem to compare the probability the null is false given either test rejects it. We find that, compared with the BMP test, the Patell test provides lower confidence that the null is false given its t-statistic is significant.

2. Description of data

Provided we had sufficient data during a 120-day estimation period as described below, we used the set of all daily CRSP return observations from 1926 to 2015 and total returns on the CRSP equally weighted index as inputs for the market model to find benchmark returns,

$$E\left(R_{i,E}\right) = \hat{\alpha}_i + \hat{\beta}_i R_{M,E} \tag{1}$$

where i denotes the firm, E the event day, M the CRSP equally weighted index, and $\hat{\alpha}$ and $\hat{\beta}$ the ordinary least squares (OLS) estimates from a 120-day estimation window ending two days prior to the event day.[3] In an effort to ensure meaningful estimates of $\hat{\alpha}$ and $\hat{\beta}$, we required a minimum of 100 observations in the 120-day estimation period preceding the event. This left us with 68,934,304 values of $E(R_{i,E})$ across 24,021 securities (PERMNOs).

Next, we formed a simulated effect of an event by adding to the actual return, $R_{i,E}$, a variable $\Delta_{i,E}$ with mean $\overline{\Delta}$ (0 or 0.25%) and a variance of θ (0 or 1) times the variance of the market-model residuals during the stock's estimation period. For example, $\overline{\Delta} = 0$ indicates there is no mean effect of the event, and $\theta = 1$ means that the effect of the event has a variance equal to the estimation-period variance of the residual. We add this simulated effect of the event to the actual return on the event day and then subtract the benchmark expected return to obtain a simulated abnormal return:

$$AR_{i,E} = \left[R_{i,E} + \Delta_{i,E}\right] - \left[\hat{\alpha}_i + \hat{\beta}_i R_{M,E}\right] \tag{2}$$

We then calculate the standardized abnormal return,

$$SAR_{i,E} = \frac{AR_{i,E}}{\sigma_i \sqrt{1 + \frac{1}{T} + \frac{\left(R_{M,E} - \overline{R}_M\right)^2}{\sum_t \left(R_{M,t} - \overline{R}_M\right)^2}}} \tag{3}$$

as per Patell (1976), with σ_i the standard deviation of the estimation period residuals and the remainder of the denominator an

[2] For researchers who do not use Eventus, a simple Matlab function that conducts event studies and calculates the Patell and BMP test statistics has been written by the authors and is available for public download at http://atc3.bentley.edu/faculty/jmarks/event_study.zip. This function can be used directly or as a guide for writing a similar function in another language.

[3] With this timing, the expected return computed in Eq. (1) is based on data independent of the actual event return (i.e. the event return and last return in the estimation window do not share a price). The results we present are unaffected by ending the estimation window on the day prior to the event date.