Event Studies

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Motivation

Reuters (March 1, 2018)

"Trump to impose steep tariffs on steel, aluminum; stokes trade war fears."

- Which industries would suffer/benefit the most from the higher tariffs?
  - ↪ What would "Siri" say?

CNBC (January 3, 2019)

"Bristol-Myers to buy Celgene in a $74 billion deal." ($102.43 per share)

- What are the chances that the deal will go through?
- Was Bristol-Myers overpaying?

CNBC (November 16, 2020)

"Moderna says preliminary trial data shows its coronavirus vaccine is more than 94% effective."

Celgene Stock Price

Outline

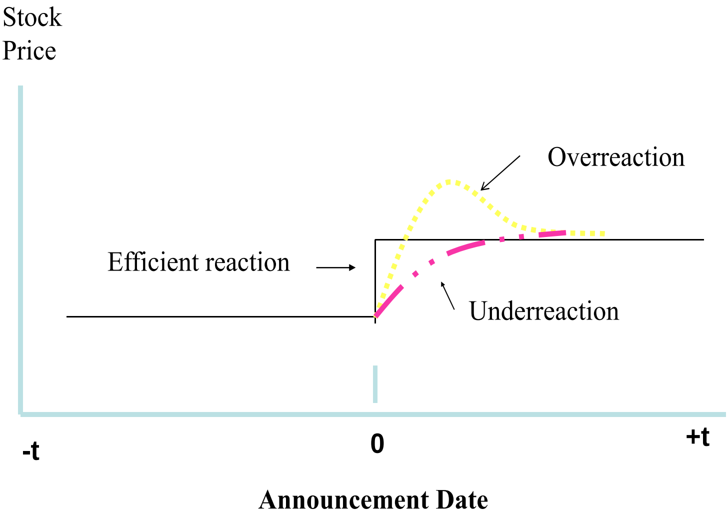
Types of Events

- Corporate events: mergers and acquisitions, stock splits, new patents
- Macro events: macro announcements (unemployment, non-farm payroll), FOMC decisions
- Policy events: changes in banking regulation, FDA decisions, SEC rulings
- Natural events: weather disaster, epidemic, climate change

Why Do Event Studies Work?

- Financial markets are forward looking.
- If the markets are informationally efficient, then the short-run price reaction to an event should reflect investors' assessment of the impact of the news on firm/security value in an unbiased manner.
  - ↪ Separate the surprise component from the anticipated component.
- Deviations from the information-efficient benchmark: Under- and over-reaction; pre-event and post-event drifts.
  - ↪ Irrationality
  - ↪ Insider trading
  - ↪ Market frictions

Price Reactions around Event Date



Challenges of Event Studies

The concept of event studies might seem simple and intuitive, but there are several important questions regarding the implementation.

1. How to separate the price reactions to news from other unrelated movements in prices?
2. How to test for the significance of price reactions?
3. How to interpret the price reactions?

Anatomy of An Event Study

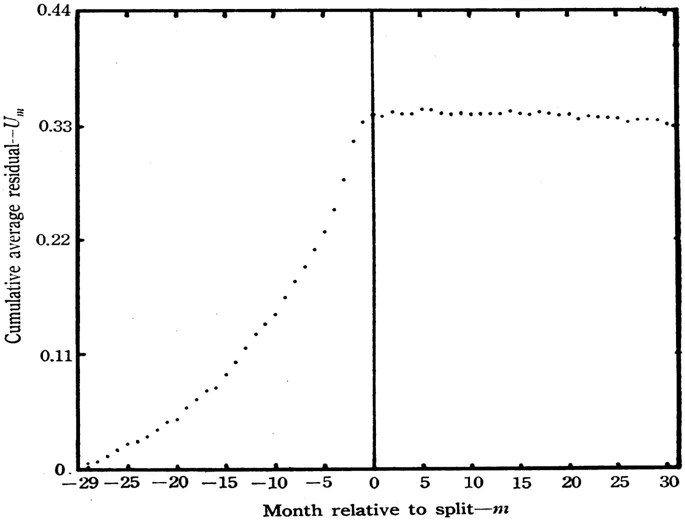
1. Event definition and event window
2. Selection criteria for firms or securities
3. Specification and estimation of reference model for "normal" returns
   - ↪ Normal vs. abnormal returns
4. Computation and aggregation of "abnormal" returns
5. Hypothesis testing
6. Interpretation

For event studies, a picture is worth a thousand words.

Outline

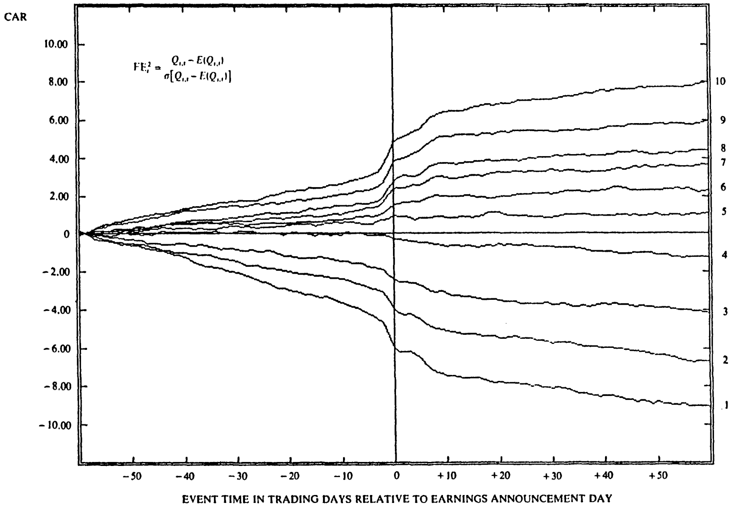
Fama, Fisher, Jensen, Roll (IER 1969)

"Effects" of stock splits on returns



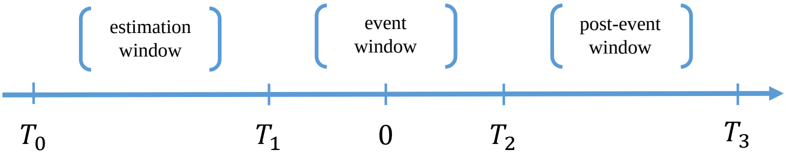
Bernard and Thomas (JAR 1985)

Post-earnings-announcement Drift (PEAD)



Outline

Event Study Setup: Timeline



- $\tau = 0$: event date
- $L_1 = T_1 - T_0$: length of estimation window
- $L_2 = T_2 - T_1$: length of event window
- $L_3 = T_3 - T_2$: length of post-event window
- N: number of securities
- $\widehat{x}$: estimate for x

Reference Model for Normal Returns

- "Normal" returns: What do we expect returns to be on non-event days?

- Common choices of models for normal returns

  1. Constant-mean-return model
  $$R_{i,t} = \mu_i + \varepsilon_{i,t}$$
  2. Market model
  $$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t}$$
  3. Linear factor model
  $$R_{i,t} = \alpha_i + \beta_i' f_t + \varepsilon_{i,t}$$

  ↪ $R_{i,t}, R_{m,t}$: period-t return on security i and the market portfolio.
  ↪ f_t: $(k \times 1)$ vector of factors (e.g., Fama-French 3-factor model).
  ↪ $\varepsilon_{i,t}$: IID normal with $\mathrm{E}[\varepsilon_{i,t}] = 0$, $\mathrm{Var}[\varepsilon_{i,t}] = \sigma^2_{\varepsilon_i}$; $\varepsilon_{i,t}$ and $\varepsilon_{j,t}$ are independent.

- Which model? Short-horizon event study results tend to be relatively insensitive to the choice of reference models. Keep it simple.

Estimating the Reference Model: Market Model

- Parameters of the reference model usually estimated over the estimation window and held fixed over the event window.
- Example: market model

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \quad \text{or} \quad R_{i,t} = x_t' \theta_i + \varepsilon_{i,t}$$

where

$$x_t' = [1 \quad R_{m,t}], \quad \theta_i' = [\alpha_i \quad \beta_i], \quad \mathbf{X} = \begin{bmatrix} x'_{T_0+1} \\ x'_{T_0+2} \\ \vdots \\ x'_{T_1} \end{bmatrix}, \quad \mathbf{R}_i = \begin{bmatrix} R_{i,T_0+1} \\ R_{i,T_0+2} \\ \vdots \\ R_{i,T_1} \end{bmatrix}$$

- Given the assumptions for $\varepsilon_{i,t}$, use the OLS estimator:

$$\widehat{\theta}_i = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{R}_i$$

$$\text{Var}[\widehat{\theta}_i] = \widehat{\sigma}^2_{\varepsilon_i}(\mathbf{X}'\mathbf{X})^{-1}$$

$$\widehat{\varepsilon}_{i,t} = R_{i,t} - x_t'\widehat{\theta}_i, \quad \widehat{\sigma}^2_{\varepsilon_i} = \frac{\sum_i \widehat{\varepsilon}^2_{i,t}}{L_1 - 2}$$

Abnormal Returns

Null hypothesis H_0

Event does not change the distribution of abnormal returns.

- To test the null, we first need to characterize the distribution of abnormal returns in the event window under H_0.
- Define $\widehat{\varepsilon}_i^*$ as the $(L_2 \times 1)$ vector of estimated abnormal returns for security i from the period $t = T_1 + 1, \cdots, T_2$.
- According to the estimated market model:

$$\widehat{\varepsilon}_i^* = \mathbf{R}_i^* - \widehat{\alpha}_i \mathbf{1} - \widehat{\beta}_i \mathbf{R}_m^* = \mathbf{R}_i^* - \mathbf{X}_i^* \widehat{\theta}_i$$

where

$$\mathbf{R}_i^* = [R_{i,T_1+1} \cdots R_{i,T_2}]', \quad \mathbf{R}_m^* = [R_{m,T_1+1} \cdots R_{m,T_2}]', \quad \mathbf{X}_i^* = [\mathbf{1} \quad \mathbf{R}_m^*], \quad \widehat{\theta}_i' = [\widehat{\alpha}_i \quad \widehat{\beta}_i]$$

Abnormal Returns

Distribution of abnormal returns

Conditional on the market returns over the event window $\mathbf{R}_m^*$,

$$\widehat{\varepsilon}_i^* \sim \mathcal{N}(0, \mathbf{V}_i)$$

where

$$\mathbf{V}_i = \mathbf{I}\sigma^2_{\varepsilon_i} + \mathbf{X}_i^*(\mathbf{X}_i'\mathbf{X}_i)^{-1}\mathbf{X}_i^{*\prime}\sigma^2_{\varepsilon_i}$$

Intuition:

- OLS is unbiased. $\mathrm{E}[\widehat{\varepsilon}_i^* | \mathbf{X}_i^*] = \mathrm{E}[\mathbf{R}_i^* - \mathbf{X}_i^*\widehat{\theta}_i | \mathbf{X}_i^*] = \mathrm{E}[\mathbf{R}_i^* - \mathbf{X}_i^*\theta_i | \mathbf{X}_i^*] =$
- $\mathbf{V}_i$ is not diagonal! Estimated abnormal returns are serially correlated due to sampling error for $\widehat{\theta}_i$.
- If the length of the estimation window L_1 is large,

$$\mathbf{V}_i \approx \mathbf{I}\sigma^2_{\varepsilon_i}$$

Aggregating abnormal returns: Over the event window

- Under H_0, abnormal returns are IID over time and across securities.
  - ↪ Aggregating over time ⇒ cumulative effect of event
  - ↪ Aggregating across securities ⇒ more precise measurement

- Cumulate abnormal returns for security i over the interval (τ_1, τ_2) (any part of the event window, i.e., $T_1 < \tau_1 \leq \tau_2 \leq T_2$):

$$\widehat{CAR}_i(\tau_1, \tau_2) = \gamma' \widehat{\varepsilon}_i^*$$

  γ: $(L_2 \times 1)$ vector with ones in positions $\tau_1 - T_1$ through $\tau_2 - T_1$ and zeros elsewhere.

- Variance of $\widehat{CAR}_i(\tau_1, \tau_2)$:

$$\mathrm{Var}(\widehat{CAR}_i(\tau_1, \tau_2)) = \sigma_i^2(\tau_1, \tau_2) = \gamma' \mathbf{V}_i \gamma$$

- Under H_0,

$$\widehat{CAR}_i(\tau_1, \tau_2) \sim \mathcal{N}(0, \gamma' \mathbf{V}_i \gamma)$$

Aggregating abnormal returns: Across securities

- Simple average of the abnormal return vectors of N securities:

$$\overline{\varepsilon}^* = \frac{1}{N}\sum_{i=1}^{N}\widehat{\varepsilon}_i^*, \quad \mathrm{Var}[\overline{\varepsilon}^*] = \mathbf{V} = \frac{1}{N^2}\sum_{i=1}^{N}\mathbf{V}_i$$

- Cumulative average abnormal returns from τ_1 to τ_2:

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

γ: $(L_2 \times 1)$ vector with ones in positions $\tau_1 - T_1$ through $\tau_2 - T_1$ and zeros elsewhere.

- Variance of $\overline{CAR}(\tau_1, \tau_2)$:

$$\mathrm{Var}(\overline{CAR}(\tau_1, \tau_2)) = \overline{\sigma}^2(\tau_1, \tau_2) = \gamma'\mathbf{V}\gamma$$

- Under H_0,

$$\overline{CAR}(\tau_1, \tau_2) \sim \mathcal{N}(\mathbf{0}, \gamma'\mathbf{V}\gamma)$$

Q: Would the results be different if we first compute $\widehat{CAR}_i(\tau_1, \tau_2)$, and then average over i?

Hypothesis Testing

Is the cumulative abnormal return for security i over (τ_1, τ_2) equal to zero?

- Standardized cumulative abnormal return

$$\widehat{SCAR}_i(\tau_1, \tau_2) = \frac{\widehat{CAR}_i(\tau_1, \tau_2)}{\widehat{\sigma}_i(\tau_1, \tau_2)}$$

- Under the null, $\widehat{SCAR}_i(\tau_1, \tau_2)$ is Student t with degrees of freedom $L_1 - 2$.

- For large estimation window (e.g., $L_1 > 30$), $\widehat{SCAR}_i(\tau_1, \tau_2) \overset{a}{\sim} \mathcal{N}(0, 1)$.

- Z-test: Reject the null if $|\widehat{SCAR}_i(\tau_1, \tau_2)| > z_{\frac{\alpha}{2}}$.

Hypothesis Testing

Is the average cumulative abnormal return for N securities over (τ_1, τ_2) zero?

- Standardized average cumulative abnormal return

$$\overline{SCAR}(\tau_1, \tau_2) = \frac{\overline{CAR}(\tau_1, \tau_2)}{\widehat{\overline{\sigma}}(\tau_1, \tau_2)}$$

- Under the null, $\overline{SCAR}(\tau_1, \tau_2) \overset{a}{\sim} \mathcal{N}(0, 1)$.

- Z-test: Reject the null if $|\overline{SCAR}(\tau_1, \tau_2)| > z_{\frac{\alpha}{2}}$.

Heteroskedasticity

- According to the null, returns in the event window have the same distribution as pre-event.
- Such a null might be too restrictive when our focus is the mean effect.
  - ↪ Various events often increase return volatilities, even if they do not affect the mean returns.
- Solution: Use cross-sectional variance of $\widehat{CAR}_i$ in the event window instead of relying on returns from the estimation window.

$$\widehat{\text{Var}}(\overline{CAR}(\tau_1, \tau_2)) = \frac{1}{N^2} \sum_{i=1}^{N} \left(\widehat{CAR}_i(\tau_1, \tau_2) - \overline{CAR}(\tau_1, \tau_2) \right)^2$$

Correlation

- So far we have assumed that abnormal returns are uncorrelated across securities.
- If event windows overlap across securities, their abnormal returns are more likely to be correlated.

  Q: Why is this a problem?
- Example: Multiple companies announce their earnings on the same day or week.
- Solution: Form a portfolio of the securities that share the same event window.

Outline

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The Pre-FOMC Announcement Drift

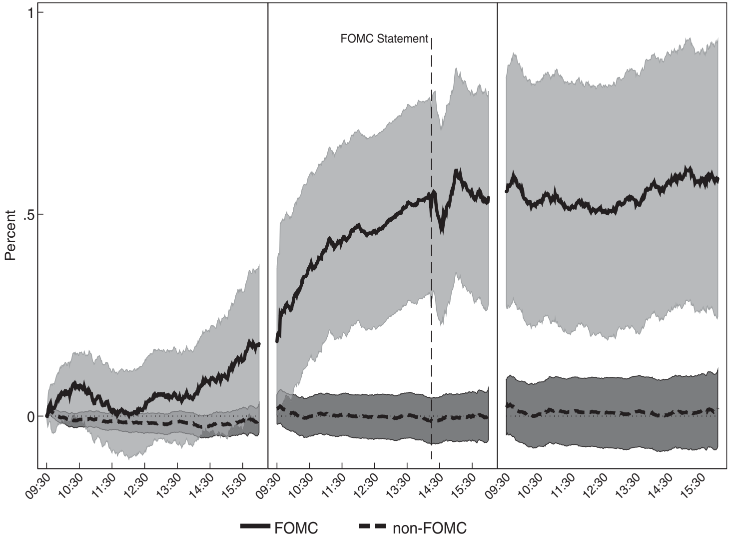
DAVID O. LUCCA and EMANUEL MOENCH*

ABSTRACT

We document large average excess returns on U.S. equities in anticipation of monetary policy decisions made at scheduled meetings of the Federal Open Market Committee (FOMC) in the past few decades. These pre-FOMC returns have increased over time and account for sizable fractions of total annual realized stock returns. While other major international equity indices experienced similar pre-FOMC returns, we find no such effect in U.S. Treasury securities and money market futures. Other major U.S. macroeconomic news announcements also do not give rise to preannouncement excess equity returns. We discuss challenges in explaining these returns with standard asset pricing theory.

Lucca and Moench (JF 2015)

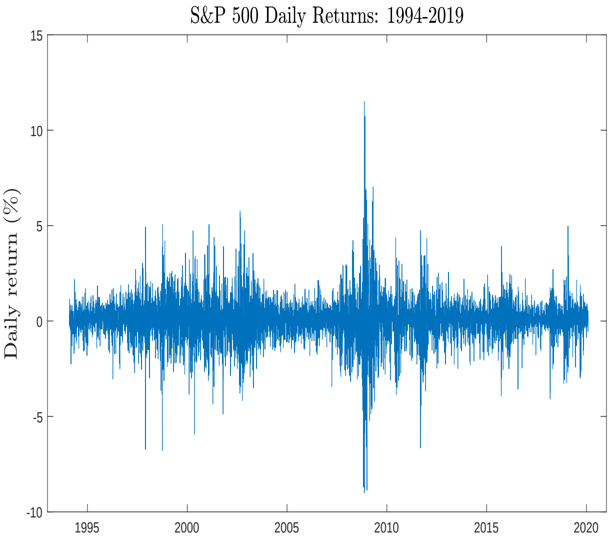
Pre-FOMC Announcement Drift in S&P 500



FOMC Announcements

- We will conduct a simpler version of event study for FOMC announcements.
  - ↪ Instead of intra-day returns, we will work with daily returns.
- Event dates: The calendar of past and scheduled FOMC meetings available at http://www.federalreserve.gov/monetarypolicy/fomccalendars.htm.
- Sample period: 1993 – 2016
  - ↪ Since 1994 the decisions of scheduled meetings have been announced to the public within a few minutes of 2:15 pm Eastern Time (ET).
- Security: S&P 500 index
- Event window: $T_1 = 0$ to $T_2 = 1$ (announcement day effect)
- Reference model: constant-mean-return model
- Estimation window: $T_0 = -249$ to $T_1 = 0$ (past 1 year)

S&P 500 Daily Returns



Is the abnormal return different on FOMC dates?

- Null: Return distribution (including mean and variance) unchanged on FOMC announcement dates.
- Average abnormal return:

$$\overline{CAR}(\tau_1, \tau_2) = 0.2880\%$$

- Variance of $\overline{CAR}$:

$$\widehat{\bar{\sigma}}(\tau_1, \tau_2) = \sqrt{\frac{1}{N^2} \sum_{i=1}^{N} \sigma_{\varepsilon_i}^2} = 0.0889\%$$

- Z-test:

$$\overline{SCAR}(\tau_1, \tau_2) = \frac{\overline{CAR}(\tau_1, \tau_2)}{\widehat{\bar{\sigma}}(\tau_1, \tau_2)} = 3.2393 > z_{\frac{5\%}{2}} = 1.96$$

Is the mean abnormal return different on FOMC dates?

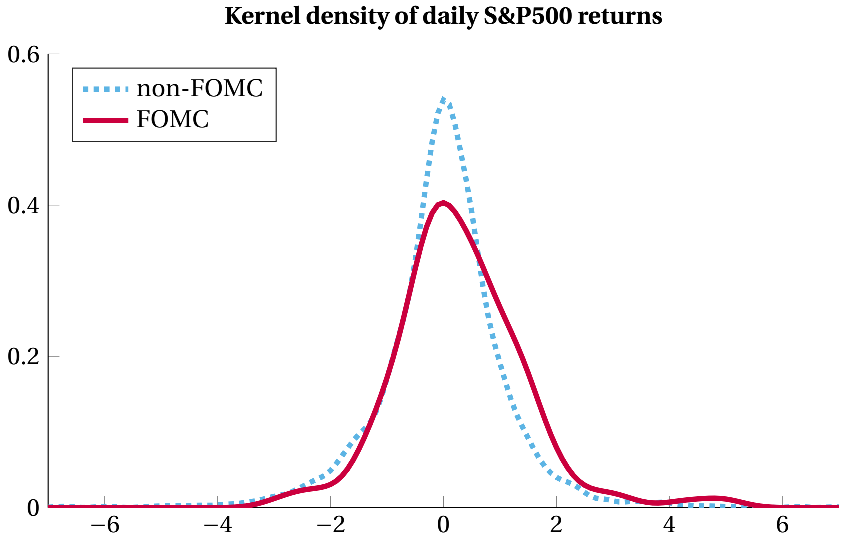
- Relaxed Null: Mean of abnormal returns unchanged on FOMC dates.

$$\hat{\sigma}(\overline{CAR}(\tau_1,\tau_2)) = \sqrt{\frac{1}{N^2}\sum_{i=1}^{N}\left(\widehat{CAR}_i(\tau_1,\tau_2) - \overline{CAR}(\tau_1,\tau_2)\right)^2} = 0.0880\%$$

- Z-test:

$$\overline{SCAR}(\tau_1,\tau_2) = \frac{\overline{CAR}(\tau_1,\tau_2)}{\hat{\sigma}(\overline{CAR}(\tau_1,\tau_2))} = 3.2728 > z_{0.025} = 1.96$$

Distribution of Abnormal Returns



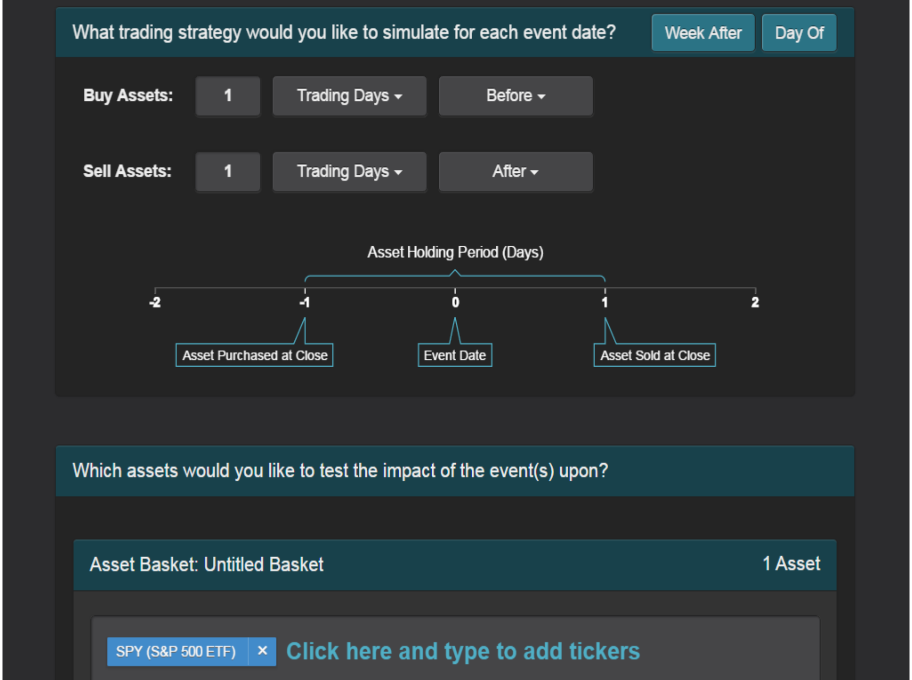
What happens after Federal Open Market Committee (FOMC) Meeting Statement Release Dates

Which event or events would you like to test the impact of?

Add an event group... | Add Custom Events | Clear All

Federal Open Market Committee (FOMC) Meeting Statement Release Dates (164 events, 164 after filters)

Date	Event Name	
2017-12-13	2017 December FOMC Meeting Statement	Scheduled
2017-11-01	2017 November FOMC Meeting Statement	Scheduled
2017-09-20	2017 September FOMC Meeting Statement	Scheduled


What trading strategy would you like to simulate for each event date?
Week After
Day Of
Buy Assets:
1
Trading Days
Before
Sell Assets:
1
Trading Days
After
Asset Holding Period (Days)
-2
-1
0
1
2
Asset Purchased at Close
Event Date
Asset Sold at Close
Which assets would you like to test the impact of the event(s) upon?
Asset Basket: Untitled Basket
1 Asset
SPY (S&P 500 ETF)
×
Click here and type to add tickers

HIDE

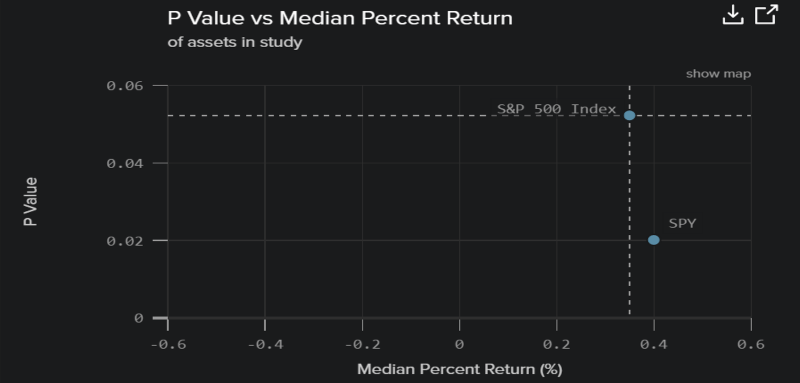
Study Results

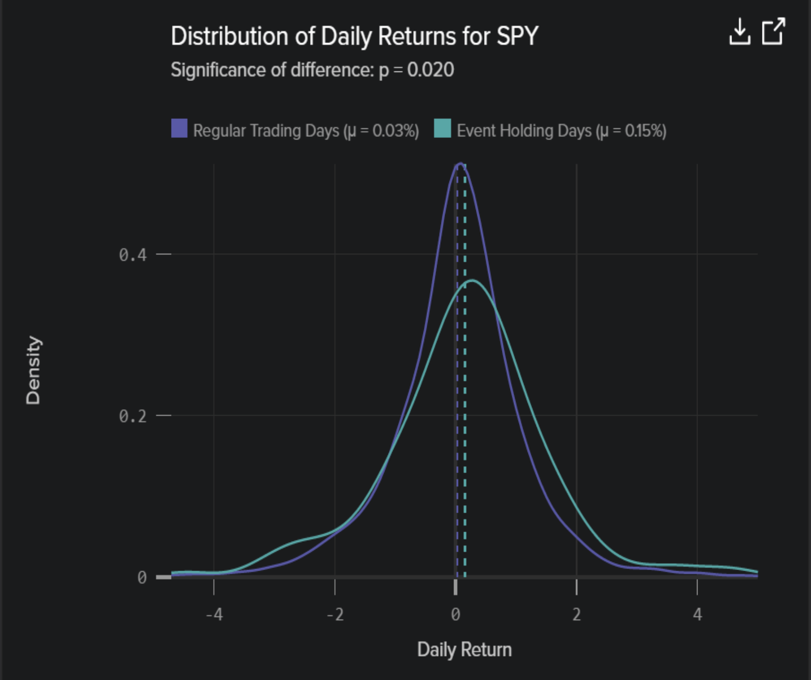
CSV

Assets			Trade Overview						Extremes	Significance
Symbol	Name	Sector	Average Trade Return	Average Excess Trade Return (vs S&P 500)	Percent of Trades Positive	Number of Trades	Average Daily Return During Trades	Percent of Days Positive During Trades		
SPY	S&P 500 ETF		0.33%	0.03%	63.87%	155	0.15%	58.12%		
^GSPC	S&P 500 Index (SPX)		0.30%	0.00%	58.71%	155	0.14%	56.17%		

HIDE

P Value vs Median Percent Return of Assets in Study Highlight Asset Toggle All




Distribution of Daily Returns for SPY
Significance of difference: p = 0.020
Regular Trading Days (μ = 0.03%)
Event Holding Days (μ = 0.15%)
Density
0.4
0.2
0
-4
-2
0
2
4
Daily Return

Readings

Supplementary readings:

- Campbell, Lo, MacKinlay, 1997, Chapter 4.
- Lucca and Moench, 2015. “The Pre-FOMC Announcement Drift,” *Journal of Finance*.