Cumulative Abnormal Returns

Calvin J. Chiou

2024-05-31

Table of contents

Introduction

In this document, we will extend the analysis from estimating the beta coefficient to measuring cumulative abnormal returns (CAR). CAR is used in event studies to assess the impact of a specific event on a stock's price. We will first estimate the market model, calculate abnormal returns, and then compute the cumulative abnormal returns.

Setup

First, we need to install and load the required packages. Ensure you have 'tidyquant', 'dplyr', 'broom', 'knitr', 'ggplot2', and 'lubridate' installed.

```
# Install the necessary packages if not already installed
if (!require(tidyquant)) install.packages("tidyquant")
if (!require(dplyr)) install.packages("dplyr")
if (!require(tidyr)) install.packages("tidyr")
if (!require(broom)) install.packages("broom")
```

```r
if (!require(knitr)) install.packages("knitr")
if (!require(ggplot2)) install.packages("ggplot2")
if (!require(lubridate)) install.packages("lubridate")
# Load the packages
library(tidyquant)
library(dplyr)
library(tidyr)
library(broom)
library(knitr)
library(ggplot2)
library(lubridate)
```

Data Collection and Manipulation

Data Download

We will download stock prices for a chosen stock (e.g., Apple Inc., ticker: AAPL) and a market index (e.g., S&P 500, ticker: ^GSPC) from Yahoo Finance during the estimation window 2020-2022. You can find any corresponding tickers that you would like to explore from its website.

```r
# Define the tickers for the stock and the market index
stock_ticker <- "AAPL"
market_ticker <- "^GSPC"

# Set the time period for the data
start_date <- "2020-01-01"
end_date <- "2023-01-01"

# Download stock and market data
stock_data <- tq_get(stock_ticker, from = start_date, to = end_date)
market_data <- tq_get(market_ticker, from = start_date, to = end_date)
```

Preview Data

Let's take a look at the first few rows of the stock data in a pretty format.

```r
# Print the head of the stock data in a pretty format
kable(head(stock_data), caption = "Stock Data: Apple Inc. (AAPL)")
```

Table 1: Stock Data: Apple Inc. (AAPL)

symbol	date	open	high	low	close	volume	adjusted
AAPL	2020-01-02	74.0600	75.1500	73.7975	75.0875	135480400	72.96047
AAPL	2020-01-03	74.2875	75.1450	74.1250	74.3575	146322800	72.25113
AAPL	2020-01-06	73.4475	74.9900	73.1875	74.9500	118387200	72.82687
AAPL	2020-01-07	74.9600	75.2250	74.3700	74.5975	108872000	72.48435
AAPL	2020-01-08	74.2900	76.1100	74.2900	75.7975	132079200	73.65034
AAPL	2020-01-09	76.8100	77.6075	76.5500	77.4075	170108400	75.21473

Data Preparation

Next, we will prepare the data by calculating daily returns for both the stock and the market index.

```
# Calculate daily returns for the stock and the market
stock_returns <- stock_data %>%
  tq_transmute(select = adjusted,
               mutate_fun = periodReturn,
               period = "daily",
               col_rename = "stock_return")

market_returns <- market_data %>%
  tq_transmute(select = adjusted,
               mutate_fun = periodReturn,
               period = "daily",
               col_rename = "market_return")

# Combine the returns data into one data frame
returns_data <- left_join(stock_returns,
                          market_returns,
                          by = "date") %>%
  na.omit()
```

Estimating the Market Model

The market model is a statistical model that describes the relationship between the returns of a stock and the returns of the overall market. We will perform a linear regression of the stock returns on the market returns to estimate the beta coefficient.

```r
# Perform the linear regression
model <- lm(stock_return ~ market_return, data = returns_data)

# Display the summary of the regression model
summary(model)
```

```
Call:
lm(formula = stock_return ~ market_return, data = returns_data)

Residuals:
      Min        1Q    Median        3Q       Max
-0.047270 -0.007389 -0.000530  0.005993  0.094904

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.0006081  0.0004786   1.271    0.204
market_return 1.1962621  0.0298684  40.051   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01316 on 754 degrees of freedom
Multiple R-squared:  0.6802,    Adjusted R-squared:  0.6798
F-statistic:  1604 on 1 and 754 DF,  p-value: < 2.2e-16
```

```r
# Extract the beta and alpha coefficients
coefficients <- tidy(model) %>%
  filter(term %in% c("(Intercept)", "market_return")) %>%
  select(term, estimate) %>%
  spread(term, estimate)

alpha_hat <- coefficients$`(Intercept)`
beta_hat <- coefficients$market_return

cat("The estimated alpha for", stock_ticker, "is", round(alpha_hat, 2), "\n")
```

```
The estimated alpha for AAPL is 0
```

```r
cat("The estimated beta for", stock_ticker, "is", round(beta_hat, 2))
```

```
The estimated beta for AAPL is 1.2
```

Calculating Abnormal Returns

Abnormal returns are the difference between the actual returns and the returns predicted by the market model.

```
# Calculate the predicted returns
returns_data <- returns_data %>%
  mutate(predicted_return = alpha_hat + beta_hat * market_return)

# Calculate the abnormal returns
returns_data <- returns_data %>%
  mutate(abnormal_return = stock_return - predicted_return)

# Display the first few rows with abnormal returns
kable(head(returns_data), caption = "Returns Data with Abnormal Returns")
```

Table 2: Returns Data with Abnormal Returns

date	stock_return	market_return	predicted_return	abnormal_return
2020-01-02	0.0000000	0.0000000	0.0006081	-0.0006081
2020-01-03	-0.0097223	-0.0070599	-0.0078374	-0.0018849
2020-01-06	0.0079686	0.0035334	0.0048349	0.0031336
2020-01-07	-0.0047031	-0.0028032	-0.0027453	-0.0019578
2020-01-08	0.0160861	0.0049025	0.0064727	0.0096134
2020-01-09	0.0212407	0.0066553	0.0085695	0.0126712

Measuring Cumulative Abnormal Returns (CAR)

Cumulative abnormal returns (CAR) are the sum of abnormal returns over a specified event window. We need to define an event date and the event window around this date.

```
# Define the event date and the event window
event_date <- ymd("2022-01-01")
event_window <- 5  # Days before and after the event date

# Filter the returns data for the event window
event_window_data <- returns_data %>%
  filter(date >= event_date - event_window &
           date <= event_date + event_window)
```

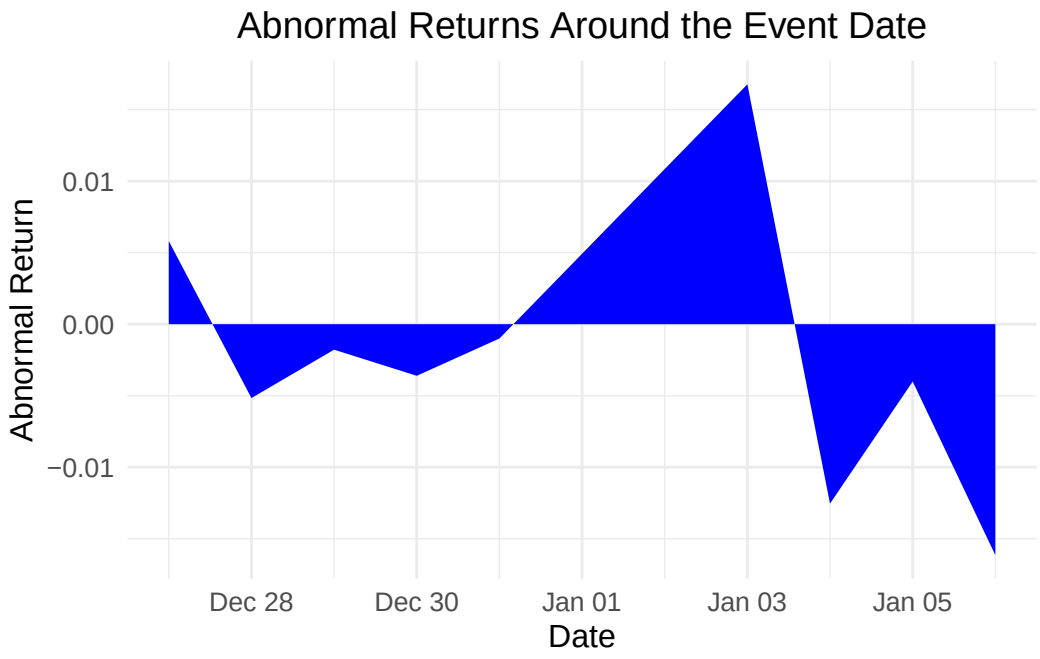
```r
# Calculate the cumulative abnormal returns (CAR)
car <- sum(event_window_data$abnormal_return)

# Display the cumulative abnormal returns
cat("The cumulative abnormal returns (CAR) for the event window around",
    as.character(event_date), "is", round(car, 4))
```

```
The cumulative abnormal returns (CAR) for the event window around 2022-01-01 is -0.0217
```

Visualizing Abnormal Returns

We will visualize the abnormal returns around the event window.

```r
# Plot the abnormal returns using ggplot2
ggplot(event_window_data, aes(x = date, y = abnormal_return)) +
  geom_area(stat = "identity", fill = "blue") +
  labs(title = "Abnormal Returns Around the Event Date",
       x = "Date",
       y = "Abnormal Return") +
  theme_minimal() +
  theme(plot.title = element_text(hjust = 0.5, size = 14),
        axis.title = element_text(size = 12),
        axis.text = element_text(size = 10))
```



Conclusion

In this document, we extended the analysis from estimating the beta coefficient to measuring cumulative abnormal returns (CAR). We estimated the market model, calculated abnormal returns, and computed the CAR for a specified event window. CAR is a useful measure in event studies to assess the impact of specific events on a stock's price.