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High-Frequency Trading Technologies

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Jerome's Market-Shaking Words:
Examining the Market Impact of Federal Funds Target Rate Releases

Introduction and Context

"When Fed Chair Jerome Powell speaks, markets all over the world surge or plunge."[1] The Federal Reserve, the U.S. Central Bank since 1913, is the body in charge of the U.S's monetary policy among other regulatory and supervisory roles. We intend to outline how one of its most well-known responsibilities, setting the federal funds target rate, affects the U.S. stock market. Our project focuses specifically on the announcement of the federal funds target range, its current market impact, its acquisition and use by trading firms, and our own custom trading implementation.

Understanding the federal funds rate requires defining a few important terms. The rate itself is the overnight interest rate which banks charge each other on loans to meet their reserve requirement.[2] This requirement is the amount of money banks are required to hold nightly with the Federal Reserve and is based on their current holdings. Since the amount fluctuates based on their holdings, some banks end up with too little and others end up with too much. So, banks loan to each other in order to meet their requirements. Although the federal funds rate may seem like a niche metric within the financial system, it trickles down through the economy and can affect interest rates for everything from credit cards to mortgages.[3]

The Federal Open Market Committee (FOMC) is responsible for establishing the target range of the federal funds rate. The committee consists of twelve members: the seven members of the Board of Governors of the Federal Reserve System; the president of the Federal Reserve Bank of New York; and four of the eleven remaining Reserve Bank presidents, who serve one-year terms. The 2025 FOMC members are Jerome Powell, John Williams, Michael Barr, Michelle Bowman, Susan Collins, Lisa Cook, Austan Goolsbee, Philip Jefferson, Adriana Kugler, Alberto Musalem, Jeffrey Schmid, and Christopher Waller.[4] The committee has eight regularly scheduled meetings per year to set a 25bps target range based on the current state of the

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[1] Vanek Smith, Stacey. "Think of the US Fed Chair as the Economy's 'Iron Throne.'" *Marketplace*, 22 Mar. 2024, https://www.marketplace.org/story/2024/03/22/think-of-the-us-fed-chair-as-the-economys-iron-throne.

[2] Federal Reserve Board. *The Federal Reserve System: Purposes & Functions – Section 3, p. 23*. Board of Governors of the Federal Reserve System, https://www.federalreserve.gov/aboutthefed/files/pf_3.pdf. Accessed 6 May 2025.

[3] "Federal Funds Rate: What It Is, How It's Determined, and Why It's Important." *Investopedia*, https://www.investopedia.com/terms/f/federalfundsrate.asp. Accessed 6 May 2025.

[4] Federal Reserve Board. "Federal Open Market Committee." *Federal Reserve Board*, https://www.federalreserve.gov/monetarypolicy/fomc.htm. Accessed 6 May 2025.

economy. The FOMC's primary goals with this rate are maximizing employment while keeping inflation in control.[5] For example, they may set a higher federal funds rate to encourage higher interest rates, lowering inflation. On the other hand, a lower federal funds rate stimulates economic growth through cheaper borrowing. During the COVID-19 pandemic, the federal funds rate was lowered to nearly 0% in an effort to encourage economic activity. The current target rate, as of May 2025, is 4.25 to 4.5%.

After the target rate is set, banks loan their reserves at rates within the target range, occasionally with some manipulation by the Federal Reserve. The effective federal funds rate (EFFR) is the volume-weighted median of these overnight transactions, currently 4.33%.[6]

The FOMC releases the new target rate and the reasoning behind it on the Federal Reserve website in a statement at 2:00 PM EST on the final day of their meeting. This project aims to analyze these statements, along with how firms are able to quickly find the information and adjust their trading strategies accordingly.

Current Landscape

Before covering our approach, it is helpful to understand the market's current response to these announcements by answering three key questions: Can the market predict what is going to happen? How do they act on it? And can you see these actions reflected in the market data?

The Federal Funds Futures contract provides the most straightforward method of understanding market expectations. There are many other methods to gauge this including the predictions of experts in news reports that may also be effective (moreso even), but these were not considered in our research. The Federal Funds Futures contract (ZQ) trades on the CME and delivers 100 minus the average daily effective federal funds rate (EFFR) for the maturity month. They are listed five years before their maturity date, so the current price illuminates the market's expectations for the rate in that month. For example, if the price of next month's contract is 96.25, then the market roughly expects that the federal funds rate will be 3.75. Using these prices with non-meeting months as "anchor months", it is possible to calculate the implied probabilities of different rate changes at a meeting. Due to the complexity, this has been omitted from the paper, but further reading can be found in the footnotes[7]. These probabilities are not based on the actual chances of a rate change, but the market's understanding of them. So, how well calibrated are they?

Research from the Federal Reserve Bank of Cleveland suggests that ZQ is biased towards overpredicting the rate change and, even when removing this bias, still consistently overpredicts

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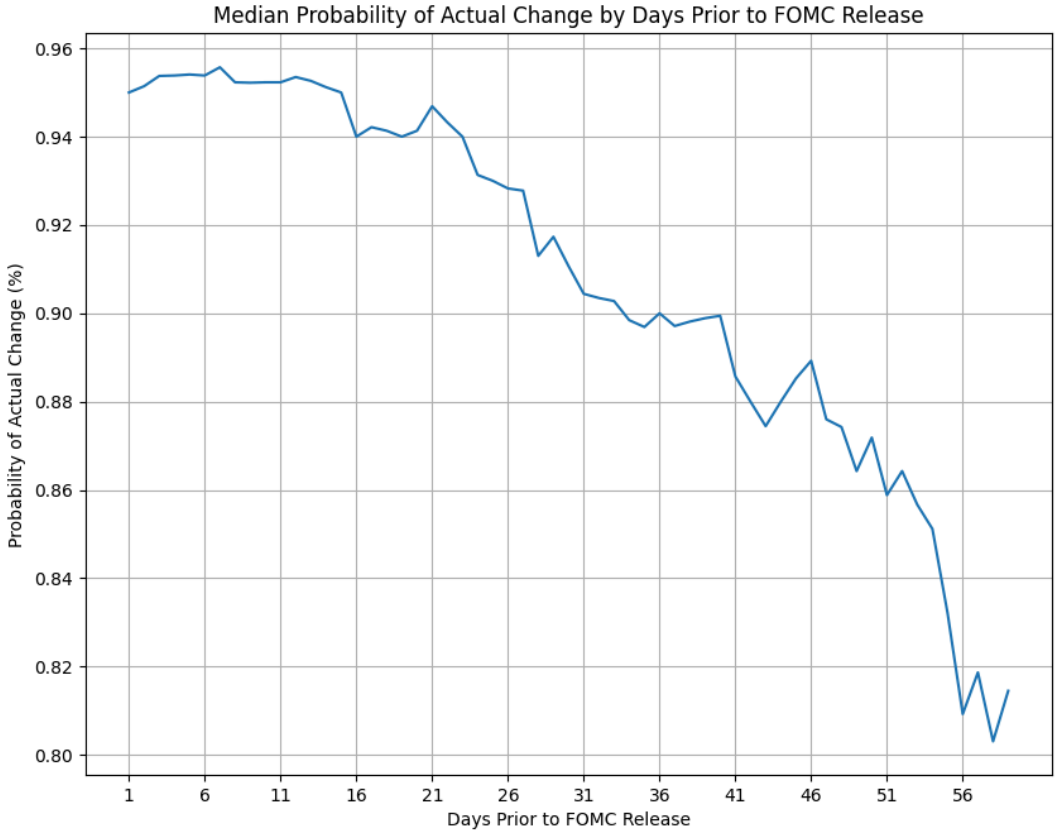
[5] Federal Reserve Bank of New York. "Monetary Policy Implementation." *Federal Reserve Bank of New York*, https://www.newyorkfed.org/markets/domestic-market-operations/monetary-policy-implementation. Accessed 6 May 2025.

[6] Federal Reserve Bank of New York. "Effective Federal Funds Rate." *Federal Reserve Bank of New York*, https://www.newyorkfed.org/markets/reference-rates/effr. Accessed 6 May 2025.

[7] Lobão, Arthur. "Understanding the CME Group FedWatch Tool Methodology." *CME Group*, CME Group, 24 Jan. 2025, www.cmegroup.com/articles/2023/understanding-the-cme-group-fedwatch-tool-methodology.html.

or underpredicts the change given the current trajectory of the rates.[8] A necessary caveat to this interpretation is that all estimations in the study were made four months prior to the rate change. While this report may deter investors from relying on these expectations that far in advance, it is not a problem for high-frequency traders, who likely care about the market expectations in the moments immediately leading up to the announcement. A more in-depth, yet older, study by the Federal Reserve of Chicago found that, with some caveats, ZQ "efficiently incorporate[s] virtually all publicly available information on the likely direction of future Funds rate movements" and "systematic changes in the Fed funds rate were accurately forecast by financial market participants".[9] While there was older data considered in this study, the major difference is that it considered the prices from one and two months out instead of four. This is consistent with our research.



[8] Nosal, Ed. "How Well Does the Federal Funds Futures Rate Predict the Future Federal Funds Rate?" *Federal Reserve Bank of Cleveland*, Economic Commentary, 1 Oct. 2001, https://www.clevelandfed.org/publications/economic-commentary/2001/ec-20011001-how-well-does-the-federal-funds-futures-rate-predict-the-future-federal-funds-rate. Accessed 6 May 2025.

[9] Krueger, Joel T., and Kenneth N. Kuttner. *The Fed Funds Futures Rate as a Predictor of Federal Reserve Policy*. Working Paper 1995-04, Federal Reserve Bank of Chicago, Mar. 1995. https://fraser.stlouisfed.org/files/docs/historical/frbchi/workingpapers/frbchi_workingpaper_1995-04.pdf. Accessed 6 May 2025.

Figure 1

Figure 1 considers all FOMC statements from 2008 to the end of 2024. For each of these statements, the probability of the actual change occurring was calculated daily up to 60 days prior and the median was plotted by day. From this graph, it is clear that ZQ predicted the actual event happening with high probability especially in the few days leading up to the release. This extreme confidence persists for about two weeks before the release at which point the confidence begins consistently dropping off. This pattern aligns with prior research, which found strong predictive power at shorter intervals before the release, while it was ineffective at four months prior.

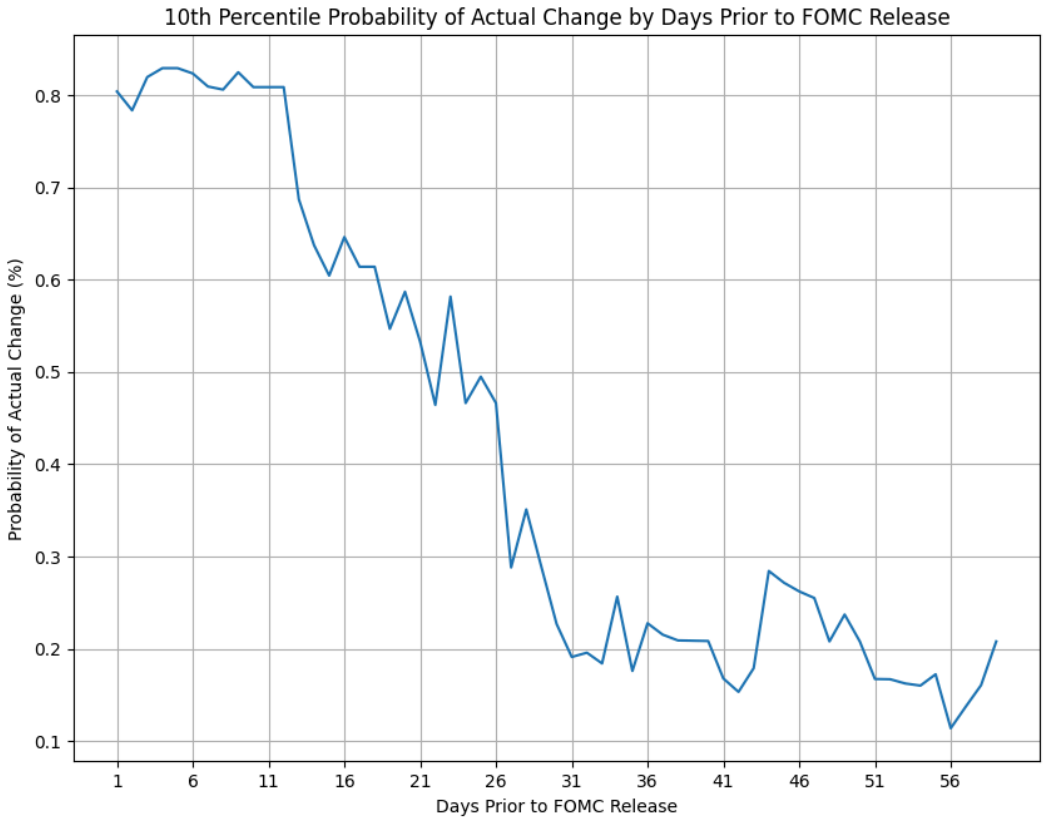


Figure 2

To further buttress this assessment, Figure 2 considers the 10th percentile of these probabilities, meaning that for 90% of the FOMC releases ZQ was more predictive than the plotted value. Even still, for roughly the two weeks prior, there was about an 80% chance of the actual event occurring. However, it drops off much further and much faster, with about a 20% chance of the actual change occurring one month prior. Thus, it is not the most likely event, since there is only one possible rate change during the period.

The futures method is less accurate when predicting releases that have a hike or drop of greater than 25bps. Overall, though, it is still a well-calibrated method of predicting the FOMC announcement.

The probability reaching its maximum and plateauing around two weeks prior to the announcement likely has two major factors. The first is, at this point, most of the necessary information for the FOMC to consider has been released including the Consumer Price Index, DOL jobs report, and more. These can be analyzed by the market to see how the FOMC might respond to them. Another factor is the FOMC's blackout period. Starting the second Saturday before the meeting (usually 10 days prior), no one with knowledge of the restricted content may talk to the press regarding monetary policy.[10] Prior to this, many of the FOMC's members, including Jerome Powell, give talks that may signal the leaning of the committee, influencing expectations.

The general public, including our group, accesses the FOMC's statements through the Federal Reserve's website. They are posted at 2:00pm on the final day of the meeting as a PDF and HTML file containing the details of the rate change and the reasoning behind it in paragraph form. For most people, this is a simple and efficient way to access the information, but there are two groups that rely on better access: news organizations and HFT firms.

As a quick aside, it is important to note that responding to news events like this release is inherently a low-frequency strategy because of how infrequently they occur. Nevertheless, it is a situation where low-latency trading, a hallmark of HFT firms, is of the utmost importance, so the phrase "HFT firms" will still be used.

Even before the advent of high-frequency trading, it was important for news organizations to respond quickly to FOMC releases. They need to efficiently inform their readers and viewers of the changing macroeconomic conditions; however, these releases and their implications can be complex, so crafting a story immediately following the release is far from ideal. The FOMC was sympathetic to these needs, so the news embargo was created. In this system, approved journalists can access the report 30 minutes prior to its release. During this time they can read and digest the statement before crafting their response to be sent to their organization at the time of release. These journalists are screened, sign documents, and give up any communication devices to ensure compliance with the FOMC's timing.

The embargo system has received significant criticism surrounding the fairness of allowing only some news organizations access as well as the dangers of giving early access to anyone outside of the FOMC. These fears were realized in 2015, when even with the safeguards, a Bloomberg journalist broke the embargo and communicated the contents of the statement before the actual statement's release.[11] This error led to an investigation by the Office of the

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[10] Federal Reserve Board. *FOMC Policy on External Communications of Federal Reserve System Staff*. 28 Jan. 2025, https://www.federalreserve.gov/monetarypolicy/files/FOMC_ExtCommunicationStaff.pdf. Accessed 6 May 2025.

[11] Yu, Robert. "Report: Bloomberg News Fires Embargo-Breaking Editor." *USA Today*, 20 Aug. 2015, https://www.usatoday.com/story/money/2015/08/20/report-bloomberg-news-fires-embargo-breaking-editor/32078587/.

Inspector General that found the need to strengthen the protections around the data.[12] Similar audits for other organizations within the government, such as the Department of Labor, led to the end of the embargo system in order to combat an unfair "competitive advantage" in trading to those that subscribed to certain news organization's data feeds.[13] However, the audit into the FOMC's processes did not lead to that conclusion, merely the strengthening of the controls around the data. Part of these recommendations included transitioning all materials involved in the embargo to a specific application which could more precisely control the release of information, track and log user behavior, and ensure viewers had completed all of the prerequisites (which were often skipped in the physical embargo room). Unsurprisingly, since then, there has been little published on the embargo system, since many of the rules are secret. Nevertheless, a 2024 Office of the Inspector General audit, revealed the embargo application passed, indicating it is still in use and the primary method of dissemination to news organizations.[14]

Since they have the data first and can convert it into a machine-readable format prior to release, these news organizations are the fastest way to get the information. Although the specific rules are not clear, this data is either sent from the journalists' laptops to the news organizations machines in a DC data center when it is ready (to be released at 2:00pm) or as soon as 2:00pm hits. HFT firms can either co-locate with the news organization in the DC data center or rely on the news organizations themselves to transport the data closer to the markets (i.e. Chicago or New York). An example of such a service is Bloomberg's EcoNext.[15]

A relatively recent discovery, the fastest way to transport financial data is via chains of microwave towers. These represent a speed-up from, fiber optic cables, the previous fastest method. Within the cables, light can only travel around two thirds of the speed of light due to refraction, while it can travel at almost the speed of light between the microwave towers. These microwave tower paths are approaching the physical limit on speed of communication, but do come with the significant downside of increased reliance on good weather conditions, so backup paths may be needed.[16]

So, HFT firms are likely using microwave towers to get the FOMC release data from DC to the markets. These could include using bandwidth from third-party providers or building their own paths. Both of these are likely scenarios. Anova announced a microwave tower route from

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[12] U.S. Office of Inspector General. *The Board Should Strengthen Controls to Safeguard Embargoed Sensitive Economic Information Provided to News Organizations*. Audit Report 2016-MO-B-006, Apr. 2016, https://oig.federalreserve.gov/reports/board-controls-sensitive-economic-information-apr2016.pdf.

[13] U.S. Bureau of Labor Statistics. "Changes to Department of Labor Media Lockup Effective March 1, 2020." *Bureau of Labor Statistics*, 15 Jan. 2020, https://www.bls.gov/bls/changes-to-dol-media-lockup-effective-march-1-2020.htm.

[14] Hasan, Khalid. *Results of Security Control Testing of the Board's Embargo Application*. OIG Memorandum Report 2024-IT-B-011R, Office of Inspector General, Board of Governors of the Federal Reserve System, 10 Apr. 2024, https://oig.federalreserve.gov/reports/board-security-control-testing-embargo-application-summary-apr2024.pdf.

[15] Brown Brothers Harriman & Co. *EcoNext Fact Sheet – U.S. Version*. https://assets.bbhub.io/professional/sites/41/EDF_EcoNext_Fact_Sheet_US_DIG1.pdf. Accessed 6 May 2025.

[16] MacKenzie, Donald. "Material Signals: A Historical Sociology of High-Frequency Trading." *American Journal of Sociology*, vol. 123, no. 6, May 2018, pp. 1453–1497. *University of Chicago Press*, https://doi.org/10.1086/697318.

DC to NY that was only 2.1km longer than the minimum allowed by the curvature of the earth in 2013.[17] These services allow HFT firms to experiment with the microwave towers without investing in their own infrastructure. However, it still can be expensive for smaller players with a single connection from Chicago to New York at a similar provider costing almost $15,000/month.[18] Even with these options, by 2014, there was still evidence of at least 15 HFT firms having custom microwave lines between New York and Chicago. So, some firms, likely the biggest players, still feel the need to create their own connections, which is likely what they have done from DC as well.[19]

Once the data reaches a New York data center, the news release can be transferred to the firm's trading machine, parsed, and an order can be sent to the co-located exchange machines to capitalize on the news. Given that the one-way latency from Chicago to NJ is less than 4ms using these microwave towers, the distance from DC to NJ is less than a third of that from Chicago, and a near-perfect path from Anova, it is likely that the DC to NJ path is nearing 1ms latencies.[20]

To understand the market's reaction to the release, we graphed the change in prices on the New York Stock Exchange on three different release dates from 1:59 PM EST to 2:01 PM.

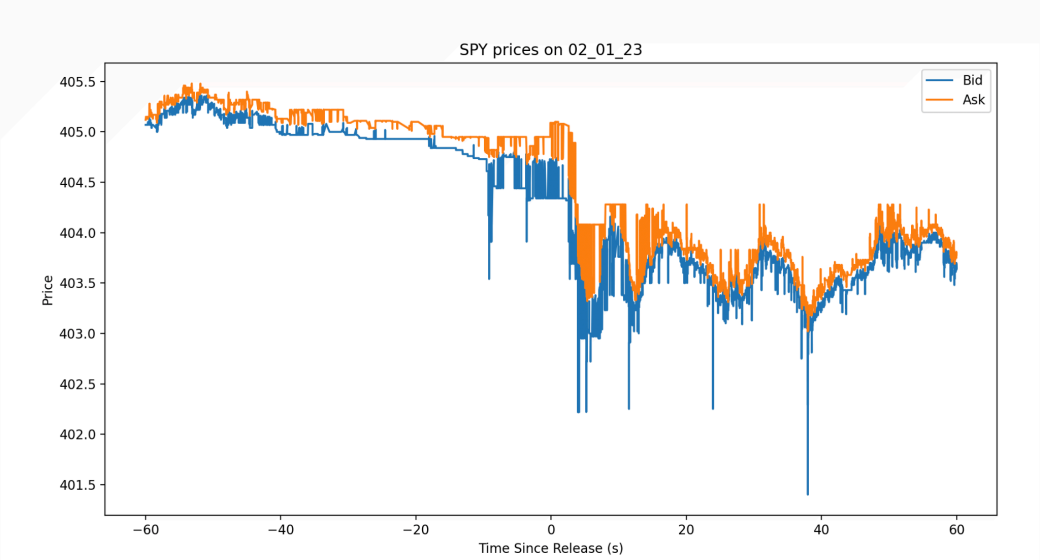

Figure 3. The price of SPY on 02/01/2023, when the federal funds rate was raised.

[17] A-Team Insight. "Towards Intelligent Trading: Anova Rolls Microwave to DC News Hub." *A-Team Insight*, 21 Mar. 2013, https://a-teaminsight.com/blog/towards-intelligent-trading-anova-rolls-microwave-to-dc-news-hub/?brand=ati.
[18] Quincy Data. *2022 QED Fee Grid*. Version 10.2, Quincy Data, Aug. 2022, https://www.quincy-data.com/wp-content/uploads/2022/08/2022_QED_Fees_Grid_proof_3.pdf.
[19] Laughlin, Gregory, Anthony Aguirre, and Joseph Grundfest. *Information Transmission Between Financial Markets in Chicago and New York*. University of California, Santa Cruz, 9 Jan. 2014, https://economics.sas.upenn.edu/sites/default/files/filevault/event_papers/LAG_final.pdf.
[20] A-Team Insight. "McKay Brothers Builds Out Low Latency Microwave Connectivity." *A-Team Insight*, 3 Mar. 2014, https://a-teaminsight.com/blog/mckay-brothers-builds-out-low-latency-microwave-connectivity/?brand=ati.

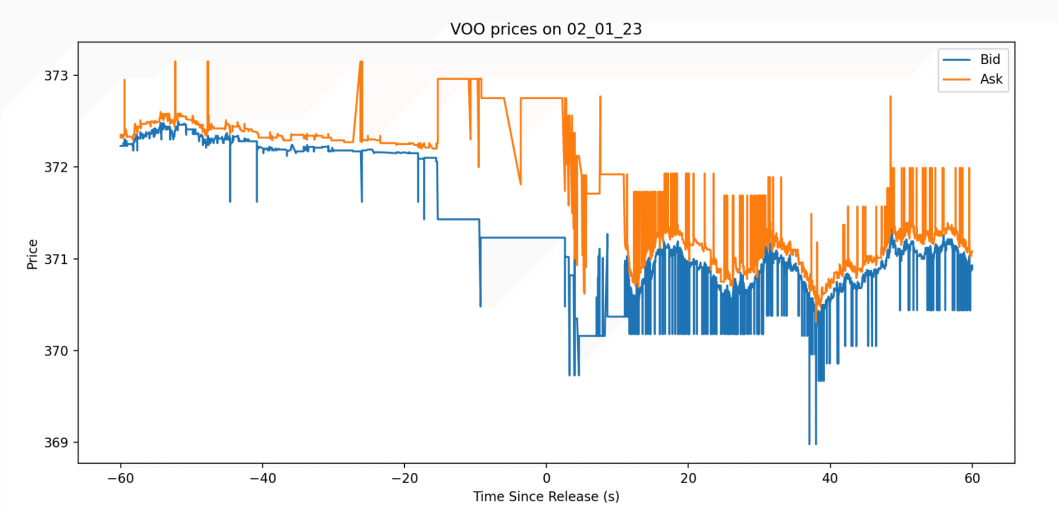

Figure 4. The price of VOO on 02/01/2023, when the federal funds rate was raised.

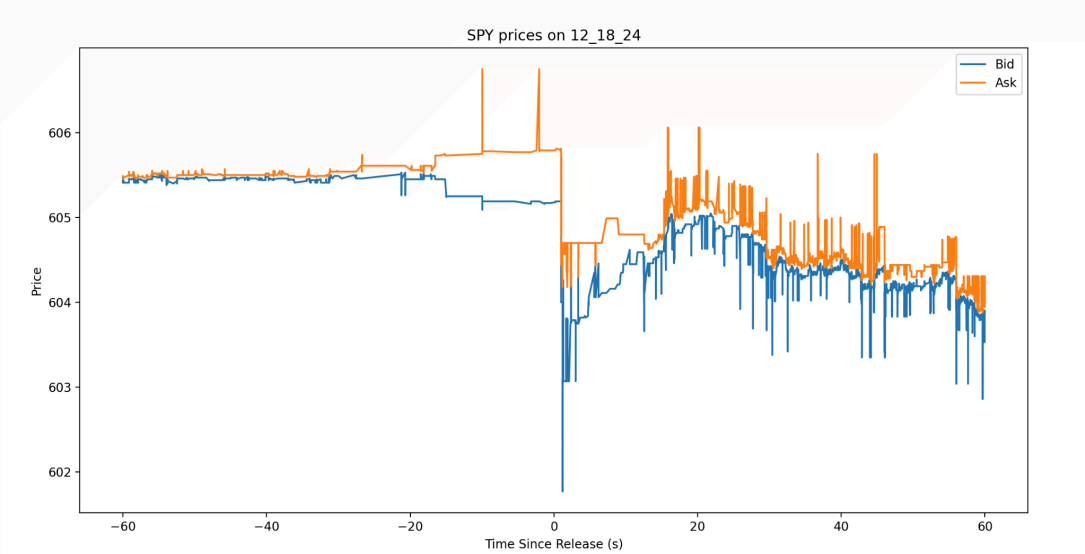

Figure 5. The price of SPY on 12/18/2024, when the federal funds rate was lowered.

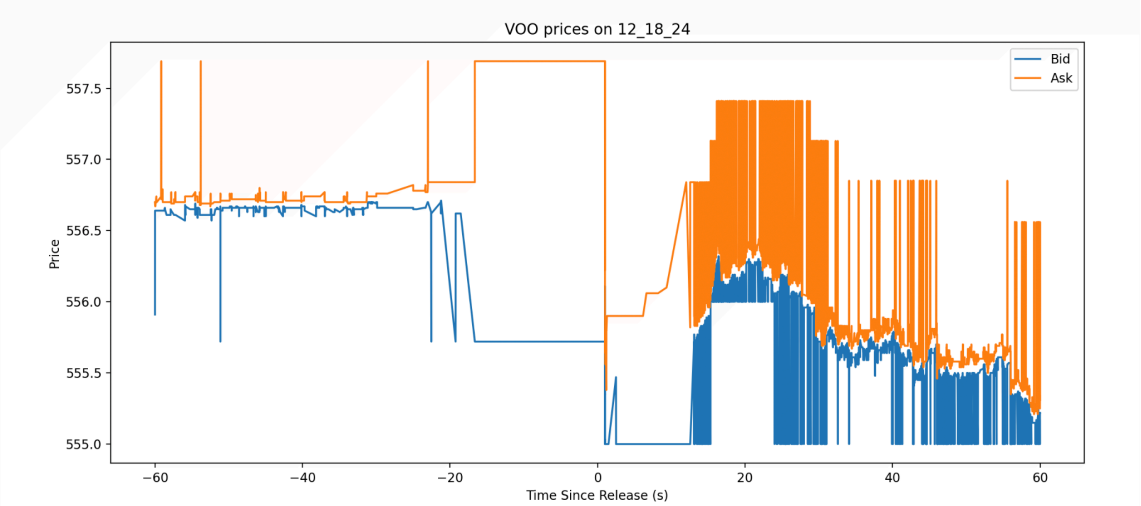

Figure 6. The price of VOO on 12/18/2024, when the federal funds rate was lowered.

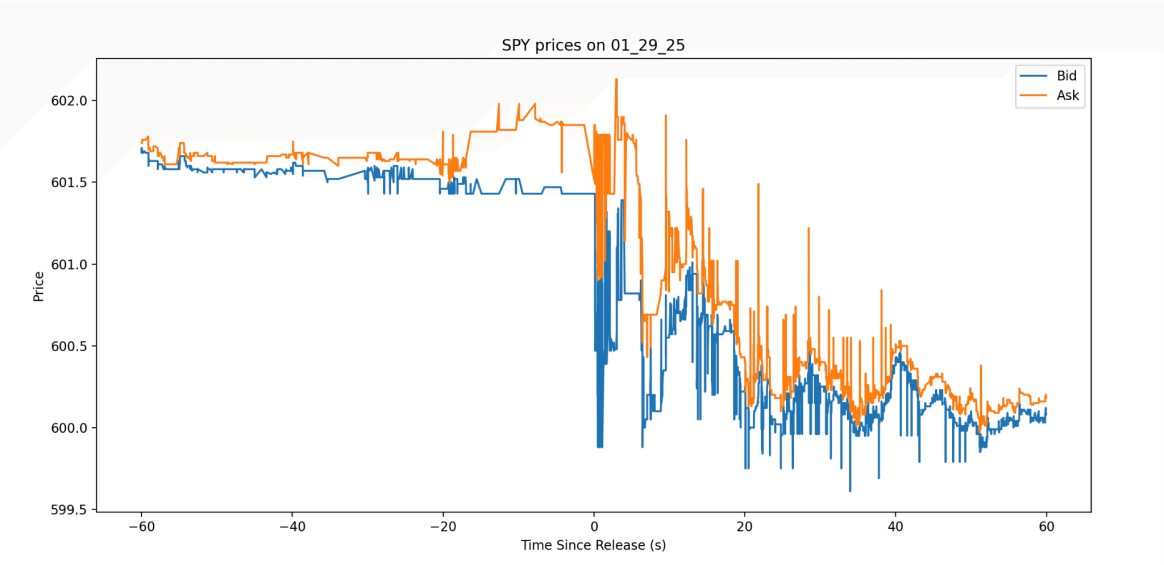

Figure 7. The price of SPY on 01/29/2025, when the federal funds rate was maintained.

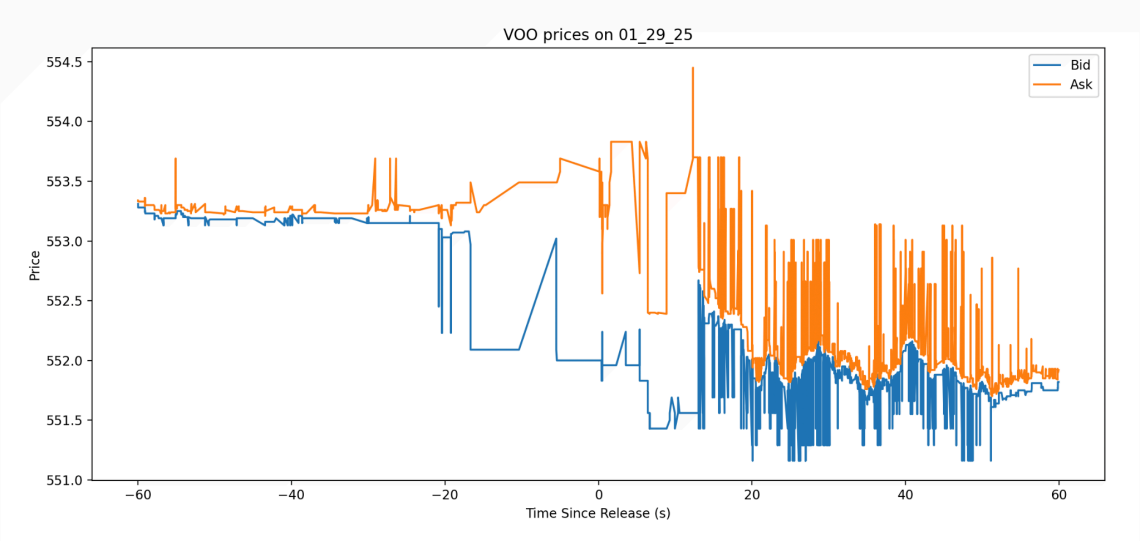

Figure 8. The price of VOO on 01/29/2025, when the federal funds rate was maintained.

From these graphs, we can see that the market responds very quickly after the release, with a drastic increase in trades occurring about 5-10 seconds after the release. The very first reactions occur milliseconds after the release. On 12/28/2024, the first drastic price change (of about $1) occurred 1.005016832 seconds after the announcement. On 01/29/2025, the first reactions occurred only 0.132287744 seconds after the release. The main thing to note is how much the frequency of trades increases within one minute of the announcement.

Our Approach

The first step in being able to quickly react to the FOMC statement is being able to extract the important information from the statement. To do this, we created a statement downloader and parser. The statement is written as a long-form paragraph with inconsistent format and wording between statements. Because of this, it is challenging to parse.

We took advantage of the HTML format of the statement in our parser. In order to access the HTML, we first created a statement downloader, intended to download the statement as soon as it is released. The program polls the expected URL of the release starting one minute before it is expected to be released, at 1:50 PM EST on a release date. If the downloader finds a “Not Found” header in the HTML description tag, it discards the response, as it is unable to be found yet. Once the downloader is able to successfully open the HTML, the program parses the statement to find the new target rate. It does this by searching for the words “federal funds rate” and then for a pattern of a number followed by the word “to” and another number. For example, it may find “4-1/4 to 4-½”. This is the target rate. The program then converts the written percentages into numbers for our system to use. For example, “4-1/4” would be converted into 4.5. Using this process, our program can download and parse the FOMC statement in approximately 30 milliseconds.

The next step we took was looking at market data to develop a strategy for reacting to the FOMC release.

One of our first attempts at the trading strategy utilizes a linear regression model that predicts market swing direction based on three key variables: actual price change (Δ), probability of that change occurring (P), and surprise factor (S). The specific regression equation is $Y = -0.02\Delta - 16.2P - 0.24S$, where Y represents the predicted market swing. The strategy follows a straightforward decision rule: BUY when the predicted swing is positive ($Y > 0$) and SELL when the predicted swing is negative ($Y < 0$). Performance metrics indicate this approach generates an average profit of $1.15 per trade, corresponding to a 0.3% return on investment. This method provides a quick framework for trade execution as shown in figure 9 below:

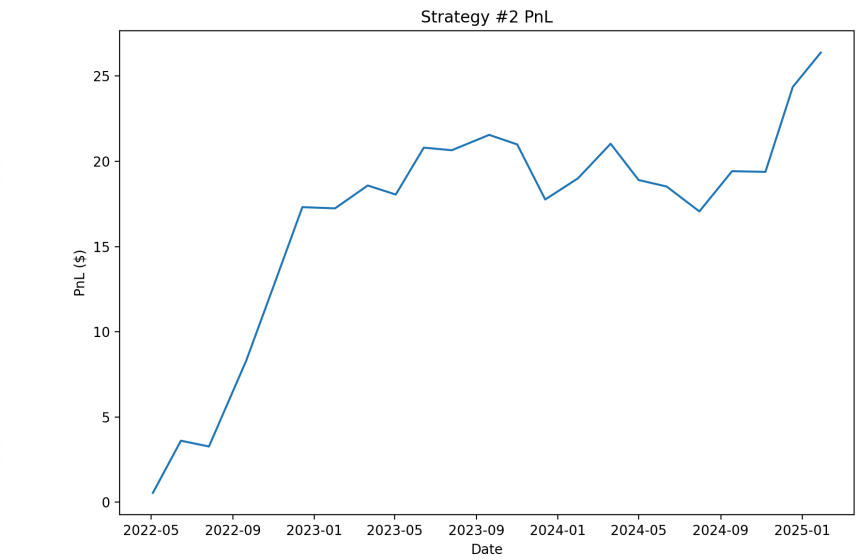

Figure 9. PnL of linear regression strategy using actual change, probability of that change occurring, and surprise

We then took another approach to compare how alternative signals may compare. We analyze market reactions through three complementary dimensions: Policy Surprise Analysis quantifies differences between expected and actual rate decisions; Market Microstructure Response examines real-time order flow dynamics during announcement windows; and Cross-Asset Confirmation verifies signal validity across related financial assets like equity indices and financial sector ETFs.

This approach produced consistent positive returns from 2022 through early 2024. Our methodology combines the above signals through linear regression and allows us to dynamically adjust position sizing based on confidence metrics. Cumulative PnL can be seen below:

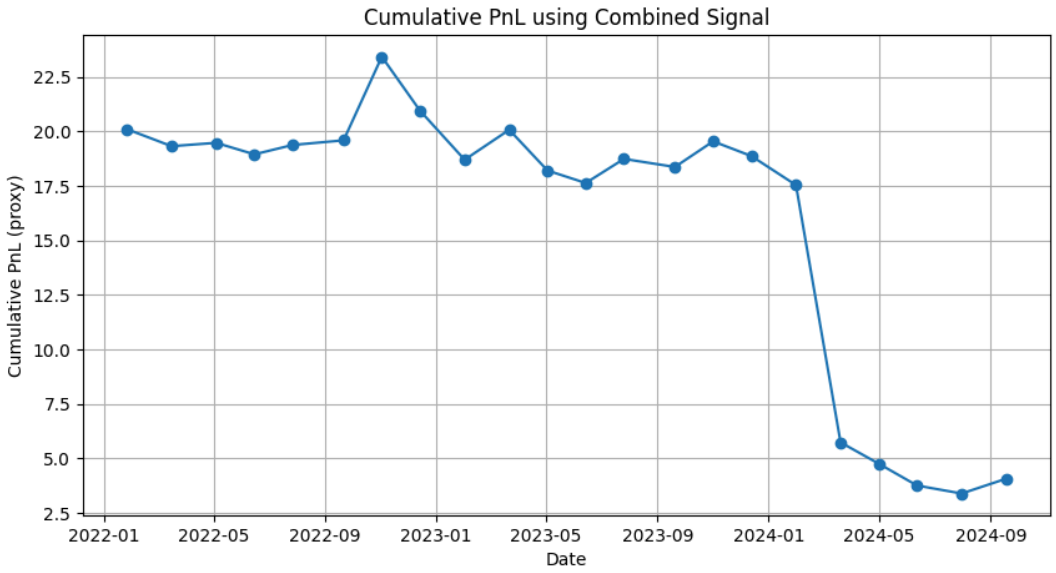

Figure 9. Cumulative PnL of surprise, order book imbalance, and cross asset confirmation

While recent performance declines indicate evolving market conditions requiring model adaptation, our backtesting confirms that analyzing the interplay between policy surprises and market microstructure provides sustainable advantage during periods of heightened volatility surrounding central bank communications. We are actively addressing these changing conditions to maintain the strategy's effectiveness in capturing alpha during these critical market events. Predicted and actual market movements can be seen in figure 10.

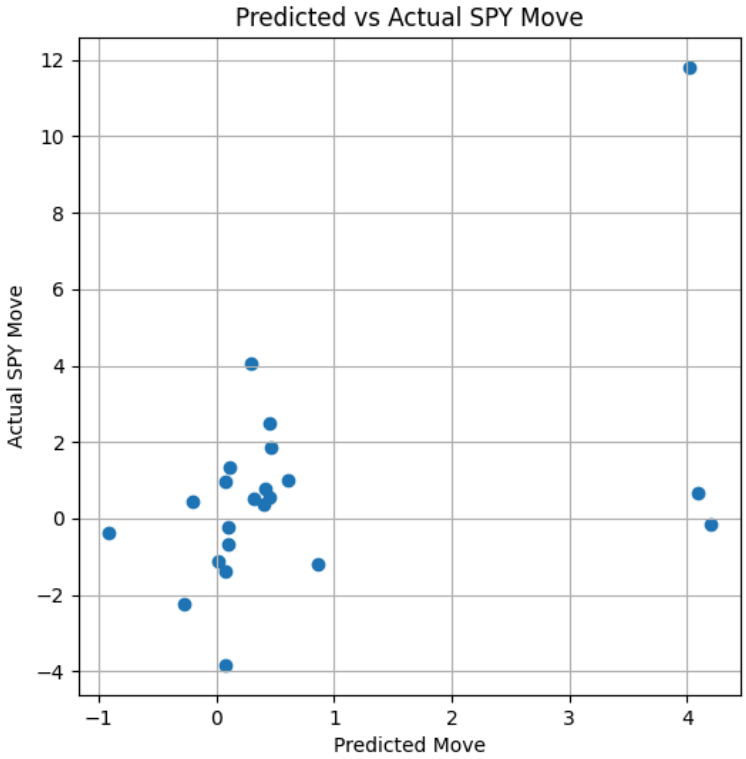

Figure 10. Predicted vs. actual market movement (SPY)