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Estimating the Effects of Monetary Policy: An Ongoing Evolution

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Introduction

Recent economic history has refocused attention on how to measure the effects of monetary policy. Events such as the global financial crisis (GFC), the COVID-19 pandemic, and the global inflationary episode that followed the pandemic have challenged popular understanding of the transmission of monetary policy and, in turn, altered how policy is implemented. But recovering the causal, empirical effect of an unanticipated change in monetary policy on the economy (known as a surprise or shock) has never been straightforward. Because monetary policy decisions reflect policymakers' reactions to the state of the economy, any developments measured after the policy decision stem from both the policy surprise and the conditions that preceded it. Disentangling the response of the economy to a policy decision from the response of the economy to macroeconomic conditions at the time of the decision is an ongoing challenge.

One popular method of separating cause from effect—high-frequency identification—analyzes the reaction of fast-moving (high-frequency) financial variables (usually asset prices) immediately following a policy announcement, within a window of time long enough for markets to respond but not so long that the response is contaminated by other information. When this method was introduced in the early 2000s, policy decisions were communicated chiefly through open market operations or the release of a discrete statement, so a very narrow measurement window likely captured reactions to policy while filtering out confounding information. However, the way monetary policy is conducted has changed considerably over time. During periods wherein the federal funds rate was pinned to the effective lower bound, policymakers turned to tools with longer

implementation times, such as forward guidance about future policy and longer-duration, large-scale asset purchases. The use of these policy tools changed not only the mix of assets that best reflect changes in policy, but also the time horizon over which news is conveyed and digested. In this article, we examine how the evolution of monetary policy has changed high-frequency identification and assess whether additional changes might be useful. Although researchers have continually updated the asset mix used in high-frequency identification over time, they have not updated the measurement window, despite significant changes in the timing of monetary policy communication. Refining the length of this measurement window may be necessary going forward to understand the effect of recent monetary policy surprises on the economy.

The article proceeds as follows. Section I discusses the conditions (or assumptions) needed to measure the effect of monetary policy and the basics of high-frequency identification. Section II discusses how high-frequency identification transformed after the GFC by integrating additional assets reflecting the monetary policy stance. Section III explores the need for further consideration of the event window as monetary policy communication continues to evolve.

I. What Is High-Frequency Identification?

To understand how changes to monetary policy influence economic outcomes, policymakers must be able to measure the effect of a policy surprise. However, economic conditions and monetary policy decisions occur simultaneously and influence one another, making it difficult to separate the response of the economy to a policy surprise from the response to other contemporaneous developments. Moreover, standard theory predicts that individuals observe the state of the economy and, with some knowledge of the central bank's priorities and mandate, anticipate future interest rate changes, adjusting their output and consumption decisions accordingly. As a result, only elements of monetary policy that are not expected by the market at the time of the announced policy change should have a detectable causal effect on real and financial variables.

Estimating the causal effect requires identifying changes in monetary policy that are unpredictable with respect to contemporaneous developments. Such "exogenous variation" in monetary policy allows us to measure how the economy reacts to those changes. The effort of recovering exogenous variation and estimating the causal effect of those changes using a combination of theory and data is called identification. The data used for this identification should have a strong and predictable

relationship to monetary policy, shifting in response to both unexpected policy changes and the absence of expected changes. This latter quality highlights why researchers cannot measure the effect of changes in monetary policy just by looking at changes in the policy rate itself—such a measurement would be unable to capture the effects of a surprise *inaction* by the central bank.

Instead, high-frequency identification measures the effect of monetary policy via high-frequency changes in financial market data—usually asset prices. Asset prices confer two key advantages for high-frequency identification. First, financial prices often adjust swiftly to new information, and changes in asset prices can be measured at daily, minute-by-minute, or even second-by-second frequencies. In addition, asset prices are not directly controlled by the central bank but react to its policy decisions. If asset market participants are rational and possess full information, then the effects of an unexpected policy change will show up immediately in asset prices following the announcement of that change, and the relationship between that variation and macroeconomic outcomes reflects the influence of policy.

However, measuring the effect of policy via changes in asset prices within an announcement window requires isolating the effect of policy from potentially confounding factors, which in turn requires four assumptions. First, we must be able to credibly assume that policymakers determine the announcement prior to observing asset price movements during the window used to measure asset price changes. In other words, we assume that members of the Federal Open Market Committee (FOMC) do not observe news and change their minds about a policy decision during the window in which we are measuring changes in asset prices. With a sufficiently narrow event window, this assumption is generally plausible: The Committee makes its policy decision and formulates its statement hours before the statement is released. Rarely is information released in the hours before an FOMC decision that could produce both asset price changes and change the minds of policymakers.

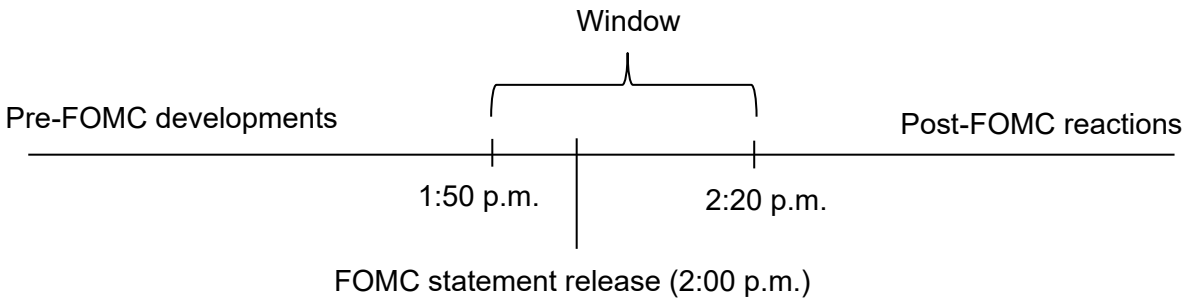
Second, we must be able to assume that no missing variables drive the asset price change during the measurement period that would also independently affect the outcome we are trying to measure. News released during the event window could affect the outcomes we want to measure, but it is unlikely to be related to the planned policy action, which is predetermined. In short, we assume that the change in the asset price used to measure monetary policy is not predictable using publicly available data.[1]

Third, we must assume that all changes in expectations about policy occur during the event window, and that any resultant changes in expectations are also fully priced during the event window. This assumption requires the window to be long enough to cover the entirety of the event (so that all monetary policy information is conveyed within the chosen interval) and long enough to cover the interval over which the public absorbs and reacts to the information.

Lastly, we must assume that the policy surprise does not reveal any information about the state of the economy that is privately held by the FOMC. All prices before the announcement must reflect full information.

The unifying theme of these assumptions—that all monetary policy news, and only monetary policy news, comes out in the window over which asset price changes are measured—has led to the adoption of increasingly narrow windows around monetary policy announcements. While early work in this vein has sometimes used daily changes in asset prices to extract monetary policy, many papers feature 90-, 60-, and especially 30-minute windows, with the open price measured 10 minutes before the release of the FOMC statement, and the close price measured 20 minutes after the announcement has concluded.

Figure 1: Announcement Timeline Example with 30-Minute Window



This narrow window reflects the discrete form generally taken by policy announcements before the GFC, which was either inferred by the size of open market operations or released in a published statement. Figure 1 shows a sample timeline for a 30-minute event window around the release of a typical FOMC statement. Within this window, investors are assumed to adjust their behavior in response to new information in the statement by rapidly buying and selling certain assets. Thus, high-frequency identification entails taking the change in the price of an asset that is affected by monetary policy from the window's open at 1:50 p.m. EST to its close at 2:20 p.m. EST.

Which assets best reflect a response to monetary policy? Early work with high-frequency identification used futures contracts based on the policy rate to measure the unexpected component of a monetary policy action. Futures prices are a natural, market-based proxy for investors' expectations because futures function like insurance against changes in the interest rate. Researchers have several short-term interest rate futures to choose from. For example, Kuttner (2001) and Faust, Swanson, and Wright (2004) use the current-month federal funds futures contract, Cochrane and Piazzesi (2002) the one-month-ahead Eurodollar deposit rate, and Rigobon and Sack (2004) the three-month-ahead Eurodollar futures rate.

The early template for high-frequency identification—short-horizon interest rate futures measured in tight intervals surrounding the release of the FOMC statement—satisfied the assumptions needed to capture exogenous variation and thus detect an economic effect from a policy surprise. However, over time, changes in how monetary policy is conducted have required additional adaptations to high-frequency identification to maintain its accuracy.

II. Developments in Monetary Policy and Revisiting the Measurement Variable

The GFC brought about two major shifts in how monetary policy is conducted: the expanded use of forward guidance and the adoption of large-scale asset purchases. The use of these two monetary policy tools calls into question whether short-term futures rates and a 30-minute event window still produce the most accurate measurement of policy effects.

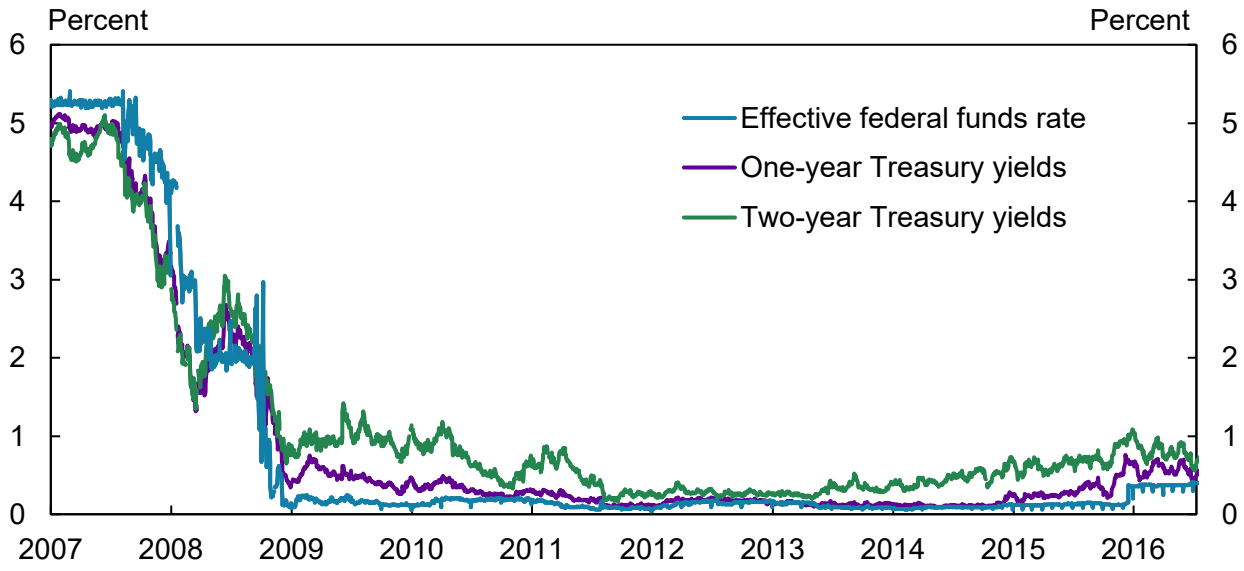
The FOMC began regularly using an early form of forward guidance in its policy statements in February 2000, including language assessing the balance of risks facing the economy. In 2003, the FOMC added guidance about the likely path of monetary policy in its statement, and in 2007, the Committee introduced the Summary of Economic Projections (SEP), which increased the frequency of released policymaker forecasts and extended the forecast horizon.

These forms of forward guidance became an important policy tool when the policy rate reached the effective lower bound in response to the GFC. By communicating a foreseen path for the federal funds rate, the FOMC can prompt the market to react to what it *says* rather than what it does when it adjusts the interest rate. Firms and individuals can then use information about future monetary policy to make longer-term financial decisions. For example, on August 12, 2003, the FOMC stated that "on balance, the risk of inflation becoming undesirably low is likely to be the predominant concern for the foreseeable future. In these circumstances, the Committee believes that policy accommodation can be maintained for a considerable period." This language suggests to the public that, barring intra-meeting developments that would dictate a tightening, the Committee did not expect to raise interest rates at the next FOMC meeting.

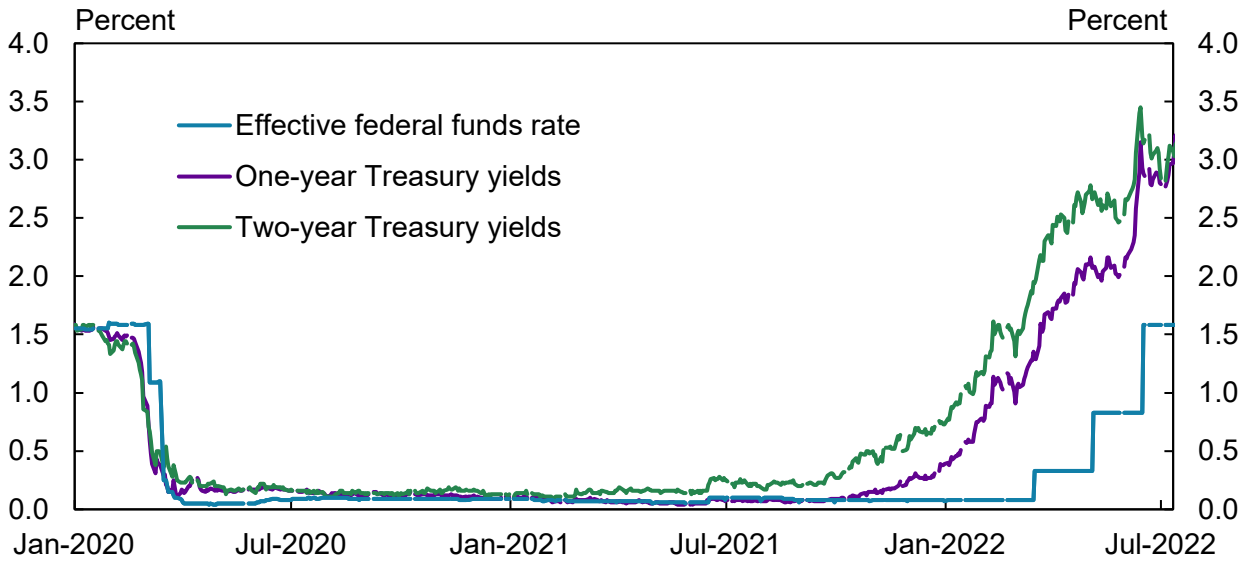
The expanded use of forward guidance transformed the task of high-frequency identification. Given that information provided to markets contains signals about the likely direction of future decisions, using asset prices that reflect only the current rate would almost surely underestimate the response. As a result, researchers now commonly use measures that capture changes in market expectations of policy over slightly longer horizons—anywhere from three months to two years—particularly when the federal funds rate is at the effective lower bound. Chart 1 shows that although the policy rate (light blue line) was pinned to near-zero during the GFC (Panel A) and early COVID-19 pandemic crisis (Panel B), one- and two-year Treasuries (dark purple and green lines) had room to move lower

Chart 1: The Monetary Policy Stance at the Effective Lower Bound

Panel A: 2007–16



Panel B: 2020–22



Sources: Board of Governors of the Federal Reserve System and Federal Reserve Bank of New York (both accessed via Federal Reserve Bank of St. Louis, FRED).

and could be influenced by forward guidance about the path of policy.

To capture changes in expectations about future meetings, many researchers use futures contracts that settle several months in the future, encompassing one or more future FOMC announcements.

A monetary policy measure of this construction considers the effect of both the change in today's interest rate (sometimes referred to as the target factor) and the effect of expected future changes (a path factor). Researchers often combine various horizons together using principal components analysis to summarize the overall stance of the monetary policy in one or two variables.

The FOMC's adoption of large-scale asset purchases (LSAPs), or quantitative easing, to loosen monetary policy at the effective lower bound also explicitly integrated longer-maturity assets into the policy tool kit. Many futures contracts commonly used in high-frequency identification, based on very short-term interest rates, became less informative when short-term rates were pinned near zero for long periods of time and, additionally, were not suitable for measuring the effect of LSAPs. After the first round of quantitative easing during the GFC, many researchers started identifying monetary policy shocks using longer-maturity assets.

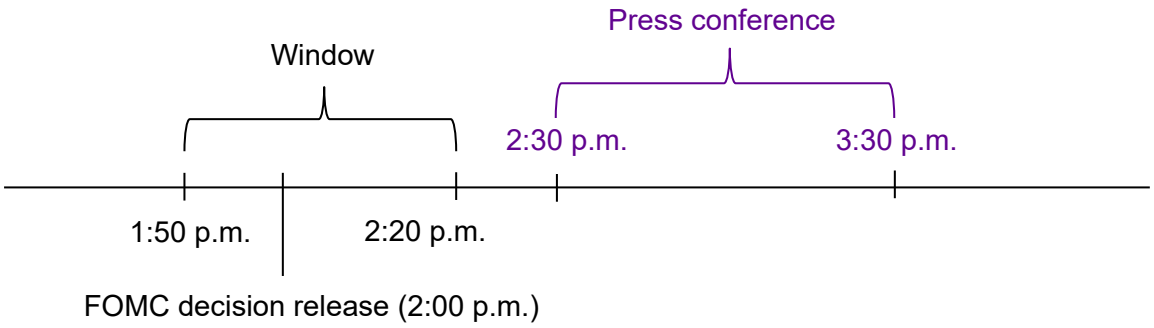
Monetary policy surprises derived from many different yields can capture policies targeting various maturities along the yield curve. As with shorter-horizon futures, researchers often combine changes in asset prices at many maturities (three-month, six-month, 12-month, two-year, five-year and 10-year, for example) to summarize the change in monetary policy. Such combined measures summarize changes to the overall stance of monetary policy both at and away from the effective lower bound. As the conduct of monetary policy has changed over time, the asset composition used to identify the effects of monetary policy has evolved to reflect those changes. However, along with changes to the maturities affected by forward guidance and large-scale asset purchases have come changes in the timing of policy communication that differ meaningfully from the pre-GFC norms. While high frequency identification has changed to reflect the asset composition of an evolving policy tool kit, modern policy communication requires also revisiting the time horizon over which policy is assessed.

III. Reconsidering the 30-Minute Window

Before the GFC, FOMC announcements and guidance about future policy were largely communicated within the FOMC statement, meaning that news was released in writing, at a discrete time, and within a discrete timeframe. Gürkaynak, Sack, and Swanson (2005) demonstrate how well a 30-minute window fully contains the reaction of the fed funds futures contract expiring within a month of the April 1992 and June 2003 FOMC announcements. In both examples, financial markets had adjusted fully to the policy announcement within minutes.

Over the last decade, however, the channels through which policy is communicated have changed considerably. Starting in 2011, a press conference with the Federal Reserve chair followed the FOMC statement releases in March, June, September, and December; since 2019, this press conference has followed every FOMC release. Between-meeting communications have also gained increasing importance, and the time needed to interpret and act on forward guidance have all extended the amount of time needed for monetary policy surprises to be fully reflected in prices.

Figure 2: Announcement Timeline Example with Press Conference



Although short event windows offer a better chance at separating reactions to monetary policy from other news that might be revealed during the day, they can also cut certain, arguably important, events short. Omissions of this type would violate the third assumption discussed in Section I—that all changes in expectations about policy occur during the event window and that these changes in expectations are fully priced during the event window. The most prominent example of news attenuation of this type is the press conference, which now can play a crucial role in forward guidance by explaining the Chair's views on policy and answering questions from the financial press.

While the FOMC's decision is still generally announced at 2:00 p.m. EST, the chair's press conference begins at 2:30 p.m. and averages around 54 minutes in duration (De Pooter 2021). Figure 2 illustrates the full timeline of FOMC communications on the day of the decision, highlighting the exclusion of the press conference from the traditional 30-minute window.

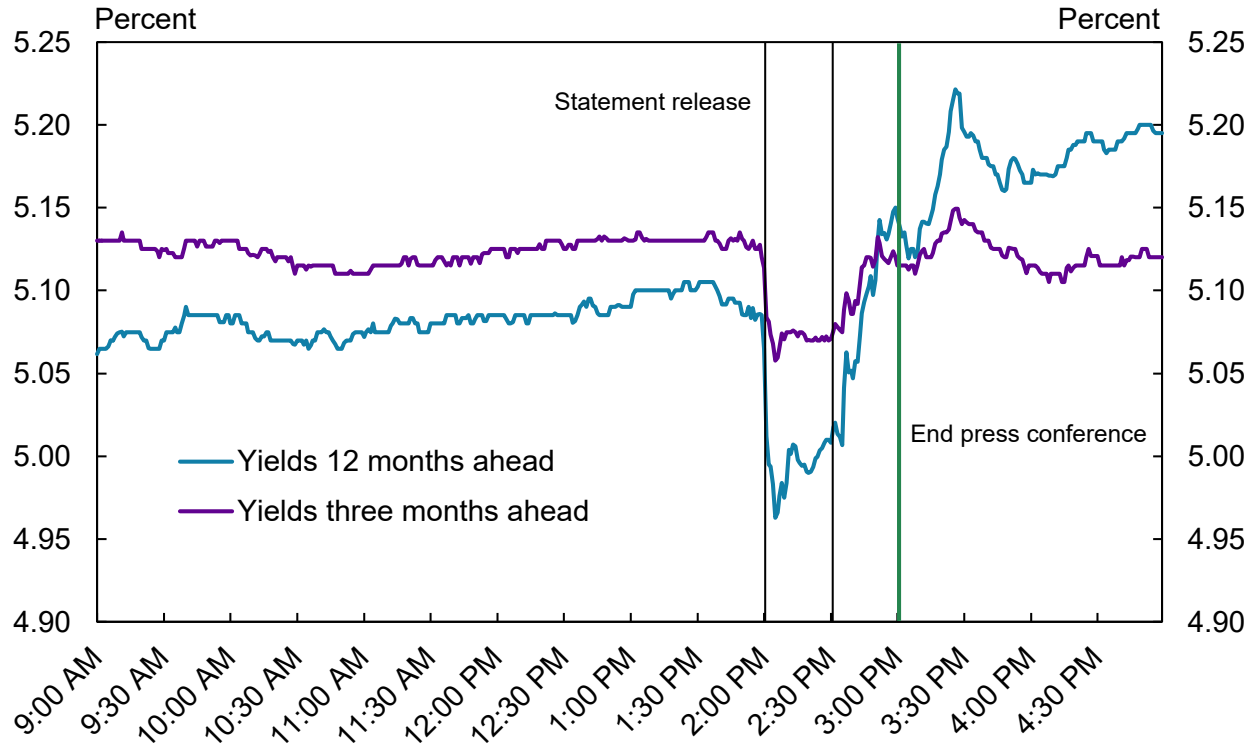
In addition to the press conference, communication between meetings has come to play an important role in shaping expectations about monetary policy. While intra-meeting speeches and interviews have produced additional events to consider in the set of policy announcements, they also leave less room for surprise upon release of the FOMC statement. Effectively, these developments have shifted the revelation of news from an event that fits well within the 30-minute window (that is, the release of the FOMC statement) toward events that are less likely to completely reveal and price information within 30 minutes (speeches and press conferences). Swanson and Jayawickrema (2024) find that speeches by the Fed Chair are in fact more influential than FOMC announcements in moving stock prices, Treasury yields, and interest rate futures of all but the shortest maturities. Although including speeches in the set of policy events offers a partial adaptation to this change, speeches, like the post-FOMC press conference, naturally run longer than the policy announcement.

Even if the event window completely bookends the release of all relevant information, markets may take additional time to process and react to an announcement. On top of the time oral remarks take to reveal information, speeches and question-answer sessions also require more subjective interpretation compared with the FOMC statement. Not only do speeches contain more text to parse, they also include nonverbal communication that informs the tone of the remarks (Gorodnichenko, Pham, and Talavera 2023).

These more recent dynamics suggest the 30-minute window is now less likely to capture the effect of a policy decision. Chart 2 shows the evolution of the implied yield on Eurodollar futures over the afternoon of November 2, 2022, when the FOMC raised the federal funds rate 75 basis points for a fourth consecutive time. The 30-minute interval around the statement, enclosed by black lines, features a *decrease* in futures-implied yields three months and 12 months ahead despite the sizeable increase in interest rates. This initial response may be explained by the context leading up to the November meeting as well as the signal conveyed by the statement. In the late summer and early fall

of 2022, market participants had begun pricing in the expectation of a pause in rate increases, and a media narrative surrounding a potential Fed "pivot" gained steam. Language in the November 2 statement (information released within the 30-minute window) may have lent credence to that narrative by referring to lags in the effect of monetary policy, leaving open the possibility of a pause at the next meeting. If we measured asset price changes only in the 30-minute statement window, we might conclude that the announcement loosened financial conditions by communicating a pause. However, in subsequent remarks at the press conference, Chair Powell provided clear signals that further rate hikes would be appropriate, and that restoring price stability would "likely require maintaining a restrictive stance of policy for some time" (Board of Governors of the Federal Reserve System 2022, p. 1). In response to pointed messaging reducing the likelihood of a pause, implied future yields rose not only during the press conference (the conclusion of which is marked by the green line) but for hours after.

Chart 2: Eurodollar Futures Continue to Process Policy News During and After the Press Conference



Source: Chicago Mercantile Exchange (Bloomberg).

The ongoing reaction to the press conference on November 2 highlights another barrier to measuring asset price responses within a narrow window—short windows around announcements may also miss slow-moving *reactions* to news. This methodological risk can be particularly acute at certain times or in particular asset markets that are of interest to policymakers and researchers. At the effective lower bound, for example, the market reaction to LSAP-related news may take additional time—both because longer-duration Treasury pricing can be more subjective, and because the Treasury investor base includes slower-moving actors compared with shorter-maturity instruments (Hanson and Stein 2015). Outside the effective lower bound, the price of assets that are harder to trade quickly, like those we might like to use to measure monetary policy's effects in smaller or less well-developed financial markets, will adjust more slowly to new information. Either cutting off the additional price movements linked to the ongoing flow of information or cutting off slow asset price reactions would contravene the assumption that the asset price fully responds to monetary policy within the time interval over which the change is calculated. As forward guidance grows in importance over time, these issues increasingly intersect.

Thus, researchers face a trade-off: A 30-minute event window is more likely to exclude news about extant economic conditions but may not fully measure the response of the asset price to policy, while asset price changes covering the entire day run the risk of including contaminating information. In practice, some of these concerns may be less salient than others, and the trade-offs likely shift with the context.

In a recent working paper, we weigh these trade-offs by comparing monetary surprises measured at intradaily (30-minute) and daily frequencies from a variety of viewpoints (An, Dilts Stedman, and Lusompa 2025). We find that the estimates produced using intradaily (30-minute) and daily measures do not, in fact, differ appreciably when the sample includes periods at the effective lower bound, suggesting that we can accommodate slower-to-develop news post-2019 without sacrificing identification. Decomposing the information flow on announcement day into information released before, during, and after the 30-minute window, we can express the reaction of any asset price on the day as the sum of price changes across the three intervals. Asset price changes during the 30 minutes around the statement are reflected in *both* the 30-minute and daily price changes. Non-monetary policy information released between the end of the 30-minute window and the end of the day, like an intentionally late-scheduled earnings announcement, is likely to be immaterial from an identification standpoint for two reasons. First, information revealed after the meeting from a non-policy source obviously cannot affect the actions of policymakers. Second, because U.S. data releases are rare in the afternoon, post-FOMC news is likely to be idiosyncratic and thus unlikely to systematically bias estimates of the effect of monetary policy. More to the point, in the case of *monetary policy news* that continues to develop or process after the narrow window has ended, those reactions arguably *should* be included in the measure of monetary policy.

The clearest concern for accurately measuring monetary policy surprises at a daily frequency, while excluding confounding information, is the release of relevant but non-policy news *ahead* of the policy announcement, such as data released in the morning. Any news relevant to the decision of policymakers occurring between the close of the previous day and the start of the announcement window has the potential to drive both policy and the variables of interest that react to it. To assess the degree of confounding news present outside a narrow window surrounding the statement, we conduct a simple statistical exercise that measures the response of daily asset price changes outside the narrow window to other data releases on FOMC announcement days. We find that most of the daily asset price change can be explained by the FOMC announcement within the window, and, critically, that what remains *cannot* be explained systematically by other data releases.

Having tested for information contamination, we find that adjusting daily price changes using predictive pre-FOMC macroeconomic data and adding speeches by the Chair allows us to faithfully

reproduce the empirical patterns traced out using intra-daily data, suggesting that daily data can indeed be a useful substitute. Our results suggest that daily and 30-minute time intervals produce similar results under specific conditions. In particular, samples including the effective lower bound feature financial market reactions that are well summarized by multi-maturity measures, which produce the most similar empirical patterns between frequencies.

We also highlight that using daily price changes may be more practical than using price changes within the 30-minute window, lowering a potential barrier to research. The construction of intraday surprises can be both costly and arduous. Although generous researchers at the European Central Bank, the Federal Reserve Bank of San Francisco, and the Bank of England have started publishing the 30-minute announcement-window asset price changes needed to construct an array of monetary policy surprises for their respective markets, these databases are not a panacea (Altavilla and others 2019; Bauer and Swanson 2023b; Braun and others 2025). Which announcements constitute monetary policy news is subjective (including the decision to extend the window to cover press conferences), the assets included in the releases vary between one another (limiting comparability between central banks), and the coverage is limited to those three largest central banks. Our results suggest "high-frequency" today may not be a strict 30-minute window, and a lack of intradaily data need not impede high-frequency identification and the measurement of monetary policy effects.

Conclusion

Informed policymaking requires accurate measurement of causal effects. However, both monetary policy and its outcomes are shaped by economic developments, so simply observing the evolution of conditions following a policy decision is not enough to determine that policy shaped them. A common approach, high-frequency identification, uses changes in asset prices to capture responses to an unexpected change in policy. This method requires several assumptions: The measurement period should be narrow enough to ensure policymakers have fixed their decision, the asset price changes should incorporate only monetary policy information and no other news, the information and reaction should be fully covered by the time interval, and the public must have full information (and rational expectations) about economic conditions before the announcement.

As the conduct of monetary policy has evolved, so has the challenge of meeting the requirements of high-frequency identification. In response to these challenges, the mix of assets used to measure

policy has shifted to reflect longer-duration assets and a longer policy horizon. Research has been less apt to address a related issue: Although the conduct of monetary policy was well suited to measuring exogenous variation within a 30-minute interval before the GFC, that seems less the case today. The events of the last two decades have challenged policymakers to develop new tools in pursuit of their mandates. The expanded role of forward guidance, the growing salience of verbal communication, and the integration of longer-maturity assets in the central bank tool kit have all lengthened the interval over which news is transmitted and processed. The novelty of these strategies only elevates the importance of adapting methods as needed to more precisely measure their effects. To accommodate these changes to communication, a longer window is likely necessary. Using daily data, we show that, at the very least, the cost of using daily data across the sample—the chance that confounding factors cloud the analysis—is outweighed by the benefit, which is the chance to capture longer timed reactions that likely accompany contemporary communication.

Endnote

[1] All other things equal, macroeconomic theory suggests that when interest rates rise, economic activity decreases, and inflation falls. However, early empirical research on the effects of monetary policy violated this theory and suggested a positive relationship between the federal funds rate and inflation. This counterintuitive empirical pattern became known as the "price puzzle" (Bernanke and Blinder 1992; Christiano 1999; Sims 1992). Cieslak (2018), Schmeling and others (2022), Bauer and Swanson (2023a, 2023b) observe a substantial correlation between monetary policy surprises and publicly available macroeconomic or financial market data that predate the FOMC announcement. These authors' findings suggest that market participants may misjudge the Fed's monetary policy rule and miscalculate its sensitivity to incoming data. As a result, using changes in asset prices around a policy announcement to measure monetary policy will violate the assumption that the asset price measured before the FOMC fully reflects all available information. If monetary policy surprises are correlated with developments in the past, they cannot be considered de-linked from existing conditions. Bauer and Swanson (2023a, 2023b) suggest cleansing monetary policy surprises of news contamination by using the portion of the surprises that cannot be explained by publicly available macroeconomic data leading up to the FOMC announcement. Adjusting announcement-interval asset price changes in this way corrects for the price puzzle and strengthens the robustness of the results.

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