Forward Guidance and the Exchange rate: Empirical Evidence *

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Abstract

This paper examines the response of the spot exchange rate within a 30-minute window to economic news related to future monetary policy path. For this purpose I use high-frequency data on 7 foreign currencies vis-à-vis USD and two types of economic news for the period of 2012-2022: i) Summary of Economic Projections (SEP) released quarterly after each FOMC meeting which contains federal funds rate, GDP growth, inflation and unemployment rate forecasts ii) the short-term policy surprise component extracted from federal funds futures. There are three main findings of this paper. First, on average USD appreciates by 36 bp vis-à-vis foreign currencies in response to an unexpected 25 bp increase in the median one-year ahead target federal funds rate projections. Second, there is no evidence of anticipation or persistence effects, and the exchange rate reacts immediately to the information contained in SEP and tends to absorb the news within an hour after the release. Third, using an identification-through-censoring technique that accounts for the possible measurement errors in the survey data, we found that the classical event-study approach underestimates the impact of the FFR target level forecasts on the exchange rate.

Keywords: exchange rate, forward guidance, FOMC meeting, Fed's dot plot, unconventional monetary policies

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1 Introduction

Announcements by the Federal Open Market Committee (FOMC) are highly anticipated by investors around the world. These announcements occur regularly and are the main channel through which Fed communicates its monetary policy decisions to the market. After the 2008 financial crisis, US monetary policy was constrained by the zero lower bound (ZLB) and the announcement of the federal funds target rate was no longer an effective tool of monetary policy. Thus, Fed turned to unconventional monetary policy tools, such as forward guidance and large-scale asset purchases.

Forward guidance is the communication of the future path of monetary policy and is embedded in macroeconomic announcements by the Fed. Many related studies confirm that there is a strong link between the macroeconomic announcements and the asset prices, although the impact varies across the market and the type of announcements studied. Forward guidance was found to be an effective monetary policy tool and have a significant effect on asset prices (see Akkaya et al. [1]). Yet, it is still interesting to understand what kind of forward guidance news the market reacts to and through which channel it operates.

This paper investigates the impact of FOMC forward guidance embedded in the Summary of Economic Projections (SEP) on currency and stock markets using high-frequency data by minute. SEP can be considered as *''quantitative"* forward guidance, since it explicitly provides numerical forecasts for key economic variables. Li, Wong and Cenev (2015) note that among all asset classes exchange market is mostly driven by fundamental factors in the economy and are mostly associated with macroeconomic news than other asset classes [13]. That is why the choice of the foreign exchange (FX) market is particularly interesting, allowing us to best identify the impact of forward guidance news using the high-frequency exchange rate data. Moreover, exchange rate data has been widely used to test market efficiency. From a policy perspective, it might be useful to observe the exchange rate movements on a daily or monthly frequency, in order to see how long-lived the effects are. However, data at a lower frequency might be contaminated with other exogenous shocks in the economy, giving a distorted picture of the true effect on the exchange rate. Thus, for the purposes of this paper, I only focus on the intraday effects of the macroeconomic announcements.

This paper attempts to contribute to the literature on the effect of macroeconomic news on the exchange rate in two main ways. First, using a new measure of the macroeconomic news contained in SEP along with the traditional surprise component extracted from the federal funds futures, I show that both news are economically and statistically significant for the currency returns. Second, I contribute to the debate on the forward guidance puzzle, the effects of forward guidance on exchange rates, and the speed with which the currency market absorbs the new information. In particular, I contribute to the discussion about the implications of the standard New Keynesian model of small open economy, which states that the longer is the horizon of an announced interest rate cut, the larger should be an effect. Indeed, the results indicate that the two-year ahead and the long-run projections do not matter, while 1-year ahead forecasts are found to have the largest effect. The median projection of the federal funds rate for the end of the next year leads to an appreciation of USD with respect to foreign currencies when monetary tightening is expected. The empirical results of this paper could be explained to some extent through the simple behavioral model developed by Gali (2020) [7]. Moreover, using this quantitative forward guidance news provides further evidence on the efficiency of the exchange market.

The paper is structured as follows. In section 2, I present a short review of the existing literature.

Next, I describe the sources of data and provide descriptive statistics. In sections 4 and 5 I present the empirical framework of event-study analysis and identification-through-censoring technique, and the main results, respectively. Section 6 provides a discussion of the results and its comparison to the findings in the literature and section 7 concludes.

2 Literature review

Many studies examined the effect of macroeconomic news on the exchange rate using data at varying frequencies, i.e intraday, daily, monthly. Hakkio and Pearce (1985) found that exchange rates are systematically related to unexpected monetary announcements and are unrelated to the news on inflation and real activity [8]. Further, they found little evidence of the persistence or anticipation effects of the news, suggesting the currency market efficiency. Almeida, Goodhart and Payne (1998) study the effect of US and German announcements on the DEM/USD exchange rate [2]. The German news tend to be incorporated slowly into the exchange rate compared to the US news and are smaller in magnitude, emphasizing the importance of the US policy announcements. Ehrmann and Fratzscher (2004) analyze the exchange rate data at a daily frequency and found that compared to German and euro area news, the announcements of US macroeconomic news have a larger impact on the exchange rate and that these news can explain well the direction of exchange rate developments at a monthly horizon [4]. Using DEM/USD, JPY/USD and GBP/USD and the federal funds futures changes around 42 US announcement days, Fatum and Scholnick (2007) illustrate that the exchange rate market responds only to the surprise component of the news [5]. While these studies use measures of the news about the actual announcement, I employ the news regarding the future path of the monetary policy, i.e forward guidance.

Rosa (2010) investigates the effect of US monetary policy on the level and volatility of exchange rates using an event study framework with 5 currencies vis-à-vis USD [18]. To extract the surprise component of the statements, the author analyzes both words and deeds of the Fed and creates a wording indicator. The paper finds that the news stemming from the Fed's statement along with the surprise component of the fed's monetary policy have economically and statistically significant effects on the exchange rate, implying that exchange rates are strongly impacted by the expected path of the future monetary policy. In addition, by analyzing the volatility of the exchange rates she finds that the policy decision news are absorbed within 30-40 minutes after the announcement.

Mueller, Tahbaz-Salehi, and Vedolin (2017) found that the FOMC announcements have economically and statistically significant effects on the excess returns of foreign currencies versus USD [15]. They present a model of exchange rate determination similar to Gabaix and Maggiori (2015) [6], where financiers can trade in currency and face a monetary policy uncertainty. Their main results are that the excess returns consist of pre-and post-announcement components and increase with the home and foreign country interest rate differential.

A recent paper by Couture (2021) uses SEP data for the period of April 2011 to March 2019 to examine its effects on Treasury bills and notes [3]. Only the news about the changes in the median fed funds rate at lower forecast horizons were found to be significant, and news on inflation and unemployment rate do not influence Treasure bills. My paper complements the paper by Couture (2021) by extending the data into a new asset class - the currency market - and by analyzing the timing of an effect and the volatility. Moreover, in addition to OLS, I implement the identification-through-censoring technique, to account for the possibility of measurement errors.

3 Data

3.1 Data source

The data on Summary of Economic Projections (SEP) is published regularly after each FOMC meeting, starting from October 30-31, 2007 alongside the policy statements. There are eight regularly scheduled meetings of the FOMC in a year, and SEP is released quarterly in March, June, September, and December. The 7 members of the Board of Governors and the 12 Presidents of the Federal Reserve Banks each submit their individual projections about the key economic variables (change in real GDP, unemployment rate, PCE inflation, core PCE inflation) based on their own beliefs about the appropriate monetary policy. These projections are for the end of the current (h=0) and following two years (h=1,2), and the long run (LR).

In April 2011, an advanced version of the SEP which contained ranges and central tendencies of the projections was released. Starting from January 2012, alongside the aforementioned variables SEP releases contained information on the forecasts for the target level of the federal funds rate of each member of the FOMC meeting. Based on the availability of projections for the federal funds rate, the analysis period in this paper is 2012-2022. These projections on the target federal funds rate show the future path of the policy that each FOMC member believes to be the appropriate monetary policy that will satisfy the Federal Reserve's dual objective of maximum employment and price stability. These projections are represented in a plot, which is commonly known as the *Fed's Dot Plot* (see Fig. 1). The projections are rounded to the nearest eighth percent, and each dot in the figure represents the individual forecasts of the FOMC members for the end of the indicated year. Summary statistics for SEP variables are presented in Table 1.

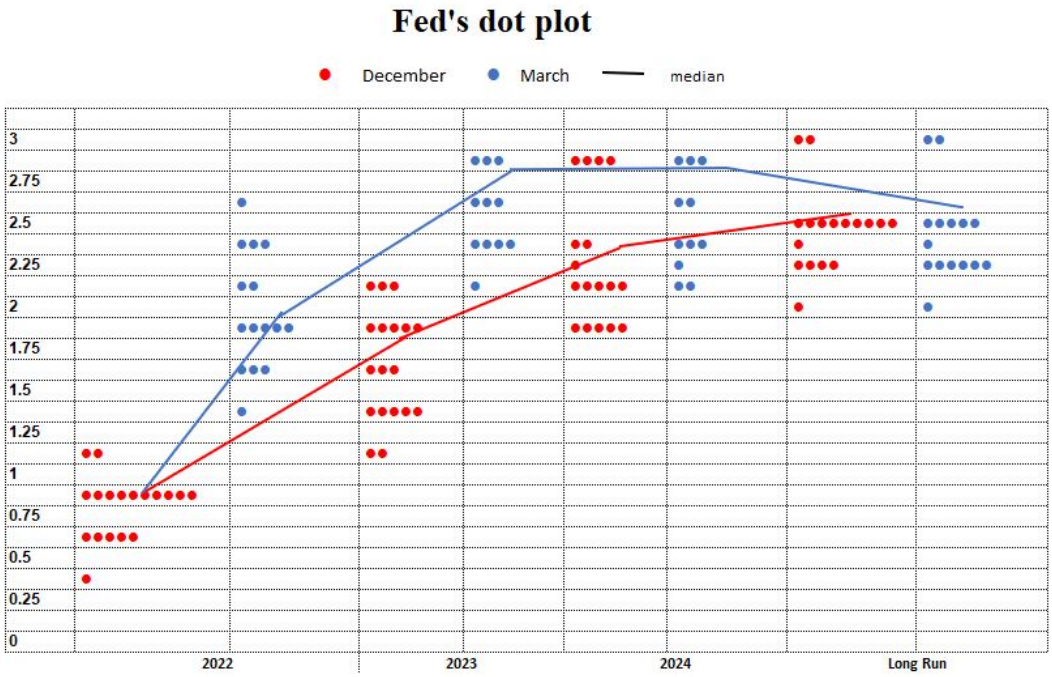

Figure 1: Fed's dot plot for December 2021 and March 2022 meetings

The data on high-frequency exchange rates comes from the historical data releases of the DukasCopy Bank, a Swiss financial services company. The data is for the period of 2012-2022 and is available by

minute. The exchange rate data is for the 7 major currencies, also known as "G7" currency pairs: Euro (EUR), Japanese yen (JPY), British pound (GBP), Swiss franc (CHF), Australian dollar (AUD), Canadian dollar (CAD) and New Zealand dollar (NZD). Alongside the return of the above currencies vis-à-vis the U.S dollar (USD), we also have the data on the trading volume. The exchange rate is taken as the average of the ask and bid prices and is defined as the amount of foreign currency that 1 unit of USD can buy, meaning that positive changes imply an appreciation of USD. Summary statistics are presented in Table 2.

Table 1: Summary Statistics for SEP

Variable	Mean	Std.Dev	Min	Max	# of obs.
Change in FFR for h=0	-0.08	0.34	-1.50	1.00	39
Change in FFR for h=1	-0.08	0.42	-1.75	1.13	39
Change in FFR for h=2	-0.10	0.45	-2.00	0.63	39
Change in PCE inflation for h=0	0.04	0.50	-1.10	1.70	39
Change in PCE inflation for h=1	-0.02	0.17	-0.60	0.40	39
Change in PCE inflation for h=2	-0.01	0.10	-0.30	0.20	39
Change in core PCE inflation for h=0	0.05	0.37	-0.90	1.40	39
Change in core PCE inflation for h=1	0.04	0.30	-0.50	1.67	39
Change in core PCE inflation for h=2	-0.01	0.09	-0.30	0.20	39
Change in unemployment rate for h=0	0.01	1.01	-1.70	5.80	39
Change in unemployment rate for h=1	-0.05	0.53	-1.00	2.90	39
Change in unemployment rate for h=2	-0.05	0.36	-0.90	1.80	39
Change in real GDP growth for h=0	-0.17	1.55	-8.50	2.80	39
Change in real GDP growth for h=1	0.06	0.55	-1.00	3.10	39
Change in real GDP growth for h=2	0.02	0.31	-0.50	1.70	39
Std.Dev of dot plot for h=0	0.14	0.12	0.00	0.44	40
Std.Dev of dot plot for h=1	0.40	0.22	0.00	0.85	40
Std.Dev of dot plot for h=2	0.62	0.27	0.06	1.20	40

Table 2: Summary Statistics for asset prices and policy surprise

Variable	Mean	Std.Dev	Min	Max	# of obs.
log changes in USD/EUR	-0.06	0.42	-1.24	0.90	41
log changes in USD/CAD	-0.06	0.38	-1.03	0.79	41
log changes in USD/CHF	-0.05	0.41	-0.98	0.86	41
log changes in USD/GBP	-0.04	0.36	-1.06	0.60	41
log changes in USD/JPY	0.01	0.36	-0.66	0.90	41
log changes in USD/AUD	-0.06	0.53	-1.05	0.96	41
log changes in USD/NZD	-0.07	0.55	-1.15	0.86	41
log changes in S&P500 index	0.07	0.50	-1.13	1.18	41
Surprise component of FFF	-0.001	0.05	-0.14	0.14	41

The data on the Federal Funds Futures (FFF) comes from a market data provider Barchart. Federal Funds Futures are traded on the Chicago Board of Trade (CBOT) starting from late 1988 and are the most widely used futures contract directly related to the federal funds rate. It is used as a hedging device, and under certain conditions, these futures contracts represent the active investor's mean expectations about the future path of the effective federal funds rate. Federal funds futures contracts are available starting from the current month up to 3 years ahead. For the purposes of this paper, I use the 30-day Fed funds futures, which are also among the most traded fed funds futures contracts. Federal Funds Futures data is necessary for the analysis to retrieve the unexpected component of the monetary policy, and the details will be described in the following sections. The data is high frequency (by minute) and

Table 3: Summary Statistics for SPD survey

Variable	Mean	Std.Dev	Min	Max	# of obs.
Change in market exp. of FFR for h=0	-0.09	0.37	-1.50	0.75	25
Change in market exp. of FFR for h=1	-0.12	0.45	-1.75	0.75	25
Change in market exp. of FFR for h=2	-0.12	0.48	-1.75	0.75	25
Change in market exp. of PCE for h=0	0.02	0.52	-1.40	1.65	39
Change in market exp. of PCE for h=1	-0.02	0.13	-0.30	0.40	37
Change in market exp. of PCE for h=2	-0.01	0.07	-0.20	0.15	39
Change in market exp. of GDP for h=0	-0.01	0.98	-2.15	4.10	39
Change in market exp. of GDP for h=1	0.03	0.47	-0.65	2.70	39
Change in market exp. of GDP for h=2	0.03	0.22	-0.50	0.80	39
Change in market exp. of UR for h=0	-0.001	1.14	-2.15	6.45	39
Change in market exp. of UR for h=1	-0.04	0.67	-1.35	3.65	39
Change in market exp. of UR for h=2	-0.09	0.29	-0.50	1.22	39

for the period of 2012-2022, and summary statistics is on table 2.

For comparative analysis, I also consider the stock markets, in particular the S&P500 index. The data for S&P500 comes from Barchart, and is high frequency, by the minute for the period of 2012-2022. Around the announcement time, the stock market operates between 9:30 am EST till 4:30 pm EST, and the data for the timing of the effects is limited for that reason. The data on the announced target rate after each meeting and the daily data on the effective fed funds rate comes from Bloomberg. In the appendix table A.3, I present the FOMC meeting dates used in this study and the associated announced target level of the federal funds rate. It is interesting to note that in table A.3 there is not much variation in the actual level of the FFR target, emphasizing the importance of the unconventional monetary policy tools such as forward guidance.

Further in the analysis, I attempt to retrieve the "unexpected" or the "surprise" component of the FOMC announcements using the expectations of the market data. For this purpose, I use the Survey of Primary Dealers (SPD), the survey conducted in advance of each FOMC meetings among primary dealers starting from 2011. Primary Dealers are trading counterparties of the New York Fed in its implementations of monetary policy. The results of the survey are published 3 weeks after each FOMC meetings. The survey results after the FOMC meetings in which SEP was published contain information on the expectations of primary dealers about the median of the projections of change in real GDP, PCE inflation, core PCE inflation, and the unemployment rate (See appendix A.1 for an example of the questions asked in SPD). Beginning in September 2015 the survey also contained a question about the expectation of the median projections of the federal funds rate by FOMC participants. I also use a Survey of Market Participants (SMP) conducted by the New York Fed, which contains a subset of the questions in the SPD and mainly targets investment firms. However, SMP contains information only about the fed funds rate. The summary statistics for SPD results are presented in Table 3.

3.2 Descriptive statistics

Alongside with the summary statistics, it is useful to present the descriptive statistics on the exchange rate volatility and trading volume on announcement and non-announcement days. Kearns and Manners (2006) document that the volatility of exchange rate is higher on event days versus non-event days [11]. From the figure 2, for the period of 2012-2022, the exchange rate volatility is higher on average for SEP publishing days, providing an initial evidence that the market reacts to these news. Volatility measure

is imputed by looking at the mean of 10-minute absolute changes in the exchange rate 2-hours before and 6-hours after SEP publishing (2 pm EST). For the non-event days, the same procedure is repeated for days exactly 1-week before and 1-week after the event, and the average of these two is used. Figure A.2 shows that on average there are no significant changes in *level* of trading volume on announcement vs non-announcement days. Yet, figure A.1 in the appendix further provides evidence that *changes* in currency trading around the SEP release is higher on the FOMC meeting days [1]. Given that trading volume fluctuations and volatility are high on the announcement days, it is important to investigate the effect of the information conveyed during these days on the exchange rate.

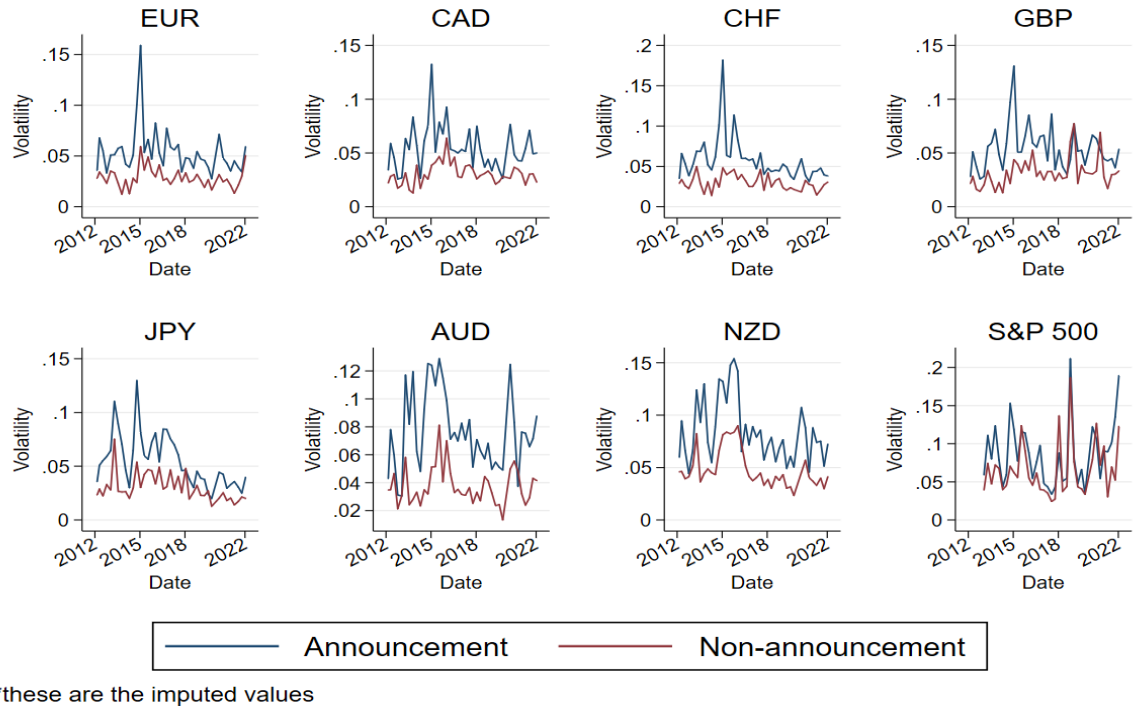

Figure 2: Volatility of asset prices

4 Estimation framework

Using the intraday data, I would like to estimate the effect of the FOMC projections on the exchange rate around the announcement time. SEP are published exactly at 2:00 pm Eastern time (EST) on the announcement day, and at 2:30 pm EST the chairman of the Board of Governors of the Federal Reserve Jerome Powell holds a press conference. Compared to other macroeconomic announcements, SEP publishing time is fixed and does not vary across meetings. I am focusing on a 30-minute window around the SEP publishing time, 10-minutes before and 20-minutes after the event. Focusing on this narrow window around the announcement ensures us that there are no other significant market news affecting the exchange rate but the SEP release.

In order to understand the general framework and motivation of the analysis, in Fig. 3 I present the exchange rate changes around the SEP publishing time for the FOMC meetings on the 20th of March in 2019 and the 16th of March in 2022. On the left panel of Fig. 3, USD is depreciating vis-à-vis EUR,

[1] Note that the S&P500 trading volume data was not available

while in the right panel there is an appreciation. Respectively, the news regarding the federal funds rate projections were different in these two meetings, with the former being associated with expected monetary policy easing and the latter with expected tightening of the monetary policy. In this way, I use this event-study analysis for the sample of 40 FOMC meetings that occurred between 2012-2022.

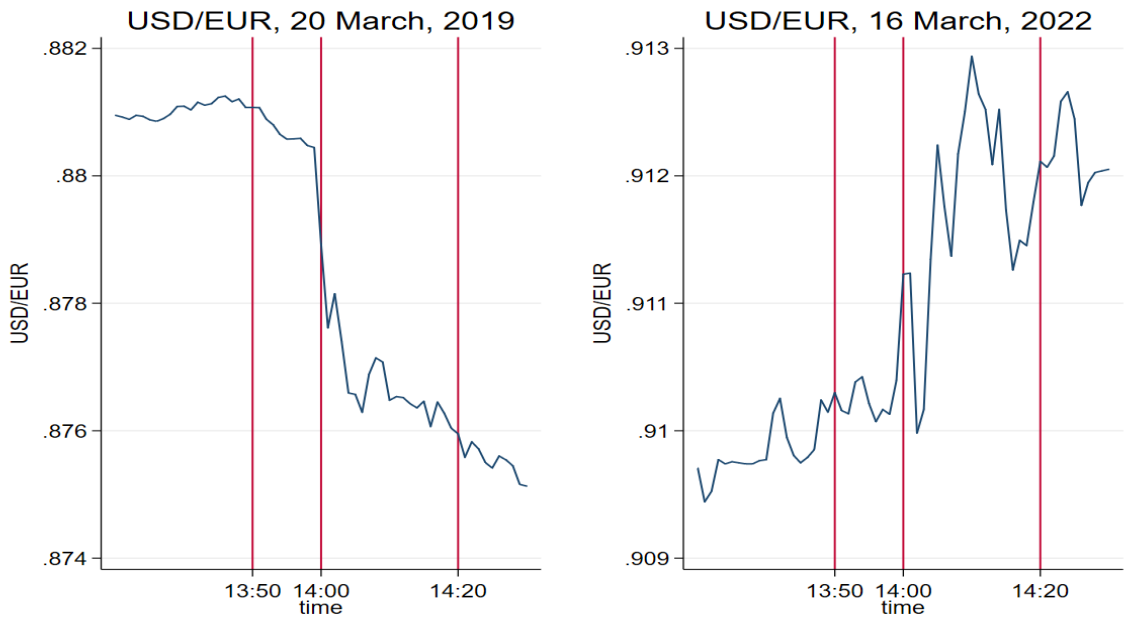

Figure 3: Changes in USD/EUR on the FOMC meeting days

The standard event study analysis method is to regress the log changes in the exchange rate on the news arriving around the announcement window, t representing the SEP publishing time [2]:

$$ln\left(S_{t+20m}\right) - ln\left(S_{t-10m}\right) = \beta_0 + \beta_1 \Delta_q x^i{}_{t,h} + \beta_2 s_t + \varepsilon_t, \quad h \;=\; 0, 1, 2, \; LR \tag{1}$$

where

S_{t-10m} – spot exchange rate at 1:50 pm EST, units of foreign currency per 1 unit of USD

S_{t+20m}– spot exchange rate at 2:20 pm EST, units of foreign currency per 1 unit of USD

s_t – policy surprise

$\Delta_q x^i_{t,h}$– quarterly changes of median projections on key economic variables published in SEP for each projection horizon h = 0, 1, 2, LR i ∈ {FFR, change in real GDP, unemployment rate, PCE inflation, core PCE}

As a measure of the macroeconomic news, I use the quarterly changes in the projections for FFR, change in real GDP, PCE inflation and unemployment rate for each projection horizon, where the projection horizon is for the end of the current (h=0) and the following two years (h=1, 2), and the long run.

[2]Note that I employ the same analysis for S&P 500 INDEX

I run the regression specification 1 separately for each of the variables for which projections are available .

In the above OLS regression framework, changes in the median projections are a measure of policy signals pertaining to longer horizons, while the policy surprise (s_t) measures a short horizon surprise. To calculate the short-run surprise, I follow the technique developed by Kuttner (2001) and use the federal funds futures. I use a 30-day federal funds futures data: the contracts with the expiry date at the end of a month and the value of the contract at the expiration date is 100-r, where r is the average effective federal funds rate for the expiry month.

The prices of the federal funds futures (FFF) are linked to the expectations of the market participants about the target level of the FFR, making it a useful tool for policy analysis. Under certain assumptions such as riskless borrowing, costless transactions, and costless storage, FFF contract prices represent market participants mean expectations for the path of the average effective federal funds rate (Moore & Austin, 2002) [14]. Kuttner (2001) shows that there is a direct link between the FOMC policy decision during the announcement days and federal funds futures [12]. I outline the main idea below.

Before the publishing the policy statement and the SEP, which occurs at 2 pm EST, FFF are determined as follows:

$$f_{t-1} = \frac{d}{m} r_{-1} + \frac{m-d}{m} E_{t-1}\left(r_0\right) + \mu_{t-1}$$

where r_{-1} is the target FFR before the announcement, and $E_{t-1}(r_0)$ is expectation of the upcoming federal funds rate after the announcement and μ_{t-1} represents a spot-month rate term premium. m is the total number of days in a given month, while d is the day of the announcement. The weights reflect the fact that FFF embody the average realized FFR through the announcement date d and the expectations about the rate after the announcement date, which comes from the structure of the price of the contract at the expiry date. Similarly, the FFF price after the announcement, i.e. when the uncertainty is resolved (2 pm EST), is :

$$f_t = \frac{d}{m} r_{-1} + \frac{m-d}{m} r_0 + \mu_t$$

In such a narrow window, the changes in the spot rate premium is negligible, so ignoring the term premium changes, we can extract the unanticipated policy surprise as:

$$s_t = r_0 - E_{t-1}\left(r_0\right) = \frac{m}{m-d}\left(f_t - f_{t-1}\right)$$

I use this measure of the surprise developed by Kuttner [12] to account for the short-run surprise that comes from the announcement of the target rate in the policy statement, which is published alongside with the SEP.

5 Empirical findings

5.1 OLS specification

First, I run OLS regression 1 for each of the variables, i.e FFR, change in GDP, unemployment rate, PCE inflation, core PCE, separately. I dropped influential observations corresponding to the second quarterly meeting of 2020 and the first quarterly meeting of 2022. In the former case, FFR projections

for all horizons were adjusted downward by more than 1 percent due to COVID-19 shock, while in the latter case there was an increase in projections by more than 1 percent due to inflationary pressures. Table 4 presents the effect of the quarterly changes in the median FFR projections on the exchange rate and the stock price index S&P500. The long-term projections were found to be insignificant for all variables, and are not presented in the table. As can be seen, projections for the end of the current year do not matter for asset prices, while the effect of the one year ahead projections are significant across all currencies and are larger in magnitude compared to the two year ahead projections. Moreover, the R^2 is larger for the one year ahead projections compared to other horizons, demonstrating its explanatory power.

Table 4: The effect of changes in the median FFR projections

	Current year			One year ahead			Two years ahead		
	change in median FFR	Surprise component	R^2	change in median FFR	Surprise component	R^2	change in median FFR	Surprise component	R^2
EUR	0.722	3.560**	0.380	0.755***	3.910***	0.500	0.506***	4.093***	0.437
	(0.465)	(1.543)		(0.240)	(1.357)		(0.158)	(1.460)	
CAD	0.625*	3.149**	0.377	0.628***	3.474***	0.480	0.355**	3.655***	0.383
	(0.323)	(1.440)		(0.196)	(1.085)		(0.150)	(1.312)	
CHF	0.663*	3.532**	0.384	0.757***	3.798***	0.526	0.538***	3.967***	0.478
	(0.380)	(1.453)		(0.184)	(1.069)		(0.112)	(1.210)	
GBP	0.680	2.476**	0.329	0.620***	2.885***	0.423	0.397***	3.037**	0.351
	(0.476)	(1.219)		(0.208)	(1.046)		(0.119)	(1.271)	
JPY	0.663**	2.179**	0.272	0.750***	2.452***	0.447	0.501***	2.648***	0.369
	(0.317)	(1.071)		(0.177)	(0.829)		(0.120)	(0.964)	
AUD	0.723	3.827**	0.280	0.728***	4.202***	0.352	0.488**	4.305***	0.303
	(0.543)	(1.677)		(0.266)	(1.619)		(0.196)	(1.471)	
NZD	0.915*	3.872*	0.307	0.905***	4.362***	0.405	0.622***	4.545***	0.354
	(0.542)	(2.055)		(0.281)	(1.574)		(0.203)	(1.477)	
S&P500	-0.475	-2.085	0.160	-0.334	-2.457	0.169	-0.404	-1.982	0.146
	(0.621)	(1.534)		(0.264)	(1.607)		(0.275)	(1.566)	
N	37			37			38		

Bootstrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

All else constant, 25 basis points (bp) increase in the FFR projections for the end of the next year (2 years ahead) leads to 19 bp (13 bp) appreciation of USD vis-à-vis Euro. Yet, the effect of the target surprise component extracted from the FFF is larger in magnitude and is significant across all currencies. On average, 25 bp increase in surprise component extracted from federal funds futures leads to 1 percent appreciation of USD with respect to EUR within 30-minute time window. This is due to the fact that in a narrow time window this surprise by construction has a direct impact on the exchange rate, being a measure extracted from the changes in the expectations of the market participants. Although insignificant, the effect of an increase in the FFR at all horizons and the policy surprise component affects negatively the stock price index S&P500. The negative sign might possibly be explained through how the market perceives the news, meaning that an expected rate increase will lead to decreased spending by consumers and businesses leading to an immediate drop in the stock prices.

The results for the effect of the changes in inflation projections on the currency and stock market are illustrated in Table 5. As for FFR, the observations for the second quarter of 2020 and the first quarter of 2022 are dropped. After controlling for FFF surprise component, there is no significant effect of changes in PCE inflation projections on both FX and stock market. The insignificance of the results might be driven by the limited data availability, yet the direction of an effect of inflation are consistent across all horizons for all currencies but JPY. The sign of the effect of inflation expectations on the currency might be either positive or negative, depending on how the market perceives the news. Hardouvelis

(1985) distinguishes two possible ways through which inflation might affect the exchange rate [10]. On the one hand, if the agents expect that the Federal Reserve will not be able to completely offset the expected higher inflation, they revise their expectations upward, leading to depreciation of USD. On the other hand, if agents expect that the rise in FFR in response to higher inflation will completely offset each other, real interest rates will be expected to rise, leading to an appreciation of USD. The results in table 5 are consistent with the latter explanation, meaning that the agents expect the Fed to respond to inflationary pressures by increasing the FFR. Indeed, this is what we have observed in May 2022 meeting, when all nine voting members of the FOMC unanimously agreed to increase the target FFR by another 50 bp. So, the results might reflect that the market believes Fed has powerful tools to curb inflation, yet we need more data to test this hypothesis.

Table 5: The effect of changes in the median PCE inflation projections

	Current year			One year ahead			Two years ahead		
	change in PCE inflation	Surprise component	R^2	change in PCE inflation	Surprise component	R^2	change in PCE inflation	Surprise component	R^2
EUR	0.219	4.395***	0.351	0.791	4.718***	0.337	0.915*	4.289***	0.325
	(0.217)	(1.302)		(0.719)	(1.588)		(0.474)	(1.630)	
CAD	0.165	3.866***	0.336	0.286	4.038***	0.310	0.527	3.791***	0.297
	(0.182)	(1.405)		(0.703)	(1.452)		(0.470)	(1.430)	
CHF	0.180	4.323***	0.353	0.718	4.586***	0.344	0.768*	4.210***	0.330
	(0.192)	(1.286)		(0.744)	(1.198)		(0.394)	(1.175)	
GBP	0.167	3.286***	0.276	0.591	3.536**	0.263	0.674*	3.197***	0.253
	(0.178)	(1.132)		(0.785)	(1.422)		(0.398)	(1.170)	
JPY	0.057	3.091***	0.207	-0.0236	3.112***	0.198	0.431	2.899***	0.188
	(0.178)	(1.199)		(0.958)	(1.063)		(0.478)	(1.034)	
AUD	0.140	4.720***	0.246	0.270	4.783***	0.229	0.913	4.473***	0.230
	(0.256)	(1.684)		(1.093)	(1.566)		(0.871)	(1.683)	
NZD	0.217	4.964***	0.263	0.917	5.242***	0.254	1.126**	4.794***	0.256
	(0.274)	(1.721)		(0.961)	(1.694)		(0.563)	(1.721)	
S&P500	-0.183	-2.546	0.146	-0.745	-2.817*	0.139	-2.045**	-2.002	0.219
	(0.202)	(1.580)		(0.863)	(1.595)		(0.951)	(1.521)	
N	36			35			39		

Bootstrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6 shows the effects of the GDP growth, unemployment rate and core PCE inflation projections on FX and S&P500. The magnitude and significance of the results imply that there is no effect of the measures of real activity, and it is true across all currencies and all horizons. This corroborates the evidence by Hakkio and Pearce (1985), who found that short-run exchange rate movements are systematically unrelated to measures of real activity [8]. After observing that the PCE inflation does not influence the exchange rate market, it is not surprising that the core PCE has no effect since the latter measure of inflation is less volatile due to the fact that it does not include food and energy prices. Given that the time window under consideration is very short, we conclude that the market does not respond to these type of news immediately.

5.2 Extracting the surprise component using SPD

In the literature, asset prices are modeled as responding to only the unexpected component of the news. Indeed, the asset view of the exchange rate and the efficient market hypothesis state that only the unexpected part of the news, i.e the "surprise component", should matter. I follow a traditional approach in the literature and extract the unexpected component of the changes in the median projections by using the survey data. For that purpose, I employ the Survey of Primary Dealers (SPD) and the Survey of

Table 6: The effect of GDP growth, UR and core PCE inflation projections

	Current year			One year ahead			Two years ahead		
	GDP	Unemployment rate	core PCE inflation	GDP	Unemployment rate	core PCE inflation	GDP	Unemployment rate	core PCE inflation
EUR	0.0378	-0.0768	0.282*	-0.0752	-0.155	0.153	-0.131	-0.186	0.851
	(0.0450)	(0.119)	(0.152)	(0.292)	(0.177)	(0.286)	-0.387	(0.156)	(0.580)
CAD	0.0388	-0.0749	0.182	-0.0942	-0.150	0.0871	-0.161	-0.174	0.701
	(0.0542)	(0.141)	(0.165)	(0.132)	(0.195)	(0.296)	-0.348	(0.138)	(0.476)
CHF	0.0175	-0.0465	0.220*	-0.0191	-0.107	0.124	-0.0569	-0.138	0.732
	(0.0335)	(0.0906)	(0.117)	(0.197)	(0.295)	(0.308)	-0.36	(0.129)	(0.483)
GBP	0.0219	-0.0522	0.200	-0.0435	-0.110	0.115	-0.0765	-0.133	0.492
	(0.0380)	(0.160)	(0.138)	(0.151)	(0.163)	(0.311)	-0.336	(0.174)	(0.532)
JPY	0.0134	-0.0411	0.114	-0.00409	-0.106	0.0633	-0.0828	-0.121	0.537
	(0.0304)	(0.117)	(0.132)	(0.165)	(0.258)	(0.205)	-0.288	(0.189)	(0.518)
AUD	0.0456	-0.102	0.265	-0.133	-0.205	0.163	-0.207	-0.234	0.862
	(0.0779)	(0.123)	(0.263)	(0.273)	(0.270)	(0.391)	-0.474	(0.284)	(0.956)
NZD	0.0312	-0.0755	0.270	-0.0665	-0.156	0.171	-0.125	-0.182	0.908
	(0.0610)	(0.148)	(0.192)	(0.295)	(0.301)	(0.352)	-0.473	(0.228)	(0.792)
S&P500	-0.0387	0.0821	-0.489**	0.108	0.160	-1.043	0.136	0.170	-1.428
	(0.127)	(0.126)	(0.222)	(0.337)	(0.242)	(0.777)	(0.507)	(0.314)	(1.521)
N		39			39			39	

Bootstrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Market Participants (SMP) conducted by the New York Federal Reserve before each meeting. The SMP includes subset of the questions in SPD and asks a subset of firms regarding their expectations for the median of the FFR projections of the FOMC members for each horizon. Since the survey question about the market expectations of the median FFR for each horizon is added to both surveys only starting from the third quarter of the year 2015 we will have less observations for FFR.

SPD contains projections about all the variables included in the SEP, while SMP provides market expectations only for the FFR. Using both SPD and SMP as a proxy for FFR expectations generates almost identical results. In order to extract the unexpected component of the changes in the variables, first I take the difference of the actual announced projections and then subtract from it the change that was expected by the primary dealers:

$$\Delta_q x_{t,h}^{unex} = \Delta_q x_{t,h} - E_{t-1}(\Delta_q x_{t,h}) = \Delta_q x_{t,h}^{SEP} - \Delta_q x_{t,h}^{SPD}$$

Table 7 below presents the effect of the "unexpected" changes in the FFR on the FX market and S&P500. Qualitatively the results are similar to the ones in Table 4, yet the projections for 2 years ahead changes are insignificant, though still positive across all currencies. This weak relationship might be due to the limited observations available or because the 2-year period might be too far away for the market to form right expectations, so that they are imprecise about their forecasts. Being imprecise about the forecasts implies larger deviations from the FOMC forecasts in SEP, and the data shows that the mean of the absolute unexpected component [3] of the FFR projections is 0.1 for 1-year ahead projections, while that of the 2-year ahead projections is 0.2, twice as large as the former one. The unexpected component of the current year forecasts are still insignificant, and this is due to the fact that in quarter 3 and 4 meetings there is almost no uncertainty about the target FFR at the end of the year, and so there is not much variation in both SEP and market projections.

Interestingly, the effect of the one-year ahead projections are highly significant and the magnitude of the effect on both currency and stock markets are larger. On average, an unexpected 25 bp increase in the FFR projections for the end of the next year leads to 36 bp appreciation of USD. The results corroborate the evidence by Couture (2021), who found that the effect of the unexpected component

[3] which is indeed the deviations of the market forecasts from that of the Fed

Table 7: The effect of changes in the median FFR projections (SPD)

	Current year			One year ahead			Two years ahead		
	change in median FFR	Surprise component	R^2	change in median FFR	Surprise component	R^2	change in median FFR	Surprise component	R^2
EUR	0.648	3.313*	0.306	1.363***	3.547**	0.563	0.417	3.430*	0.289
	(0.822)	(1.938)		(0.207)	(1.679)		(0.299)	(1.900)	
CAD	0.712	3.122	0.331	1.268***	3.404**	0.564	0.270	3.264*	0.262
	(0.701)	(1.998)		(0.288)	(1.584)		(0.329)	(1.727)	
CHF	0.549	3.384*	0.329	1.175***	3.582**	0.543	0.287	3.440**	0.289
	(0.714)	(1.933)		(0.282)	(1.499)		(0.348)	(1.614)	
GBP	0.770	2.303	0.302	1.175***	2.629*	0.536	0.330	2.511	0.230
	(0.663)	(1.654)		(0.217)	(1.418)		(0.295)	(1.535)	
JPY	0.670	2.626*	0.282	1.427***	2.867**	0.639	0.340	2.717*	0.229
	(0.647)	(1.544)		(0.275)	(1.304)		(0.377)	(1.464)	
AUD	1.292	3.523	0.320	1.775***	4.089	0.521	0.478	3.854*	0.219
	(0.881)	(2.232)		(0.424)	(2.549)		(0.393)	(2.241)	
NZD	1.170	3.728*	0.307	1.833***	4.217*	0.543	0.481	4.019*	0.231
	(0.984)	(2.006)		(0.372)	(2.213)		(0.475)	(2.324)	
S&P500	-1.292**	0.0260	0.294	-1.297***	-2.479*	0.501	-0.502	-1.753	0.125
	(0.521)	(0.0620)		(0.258)	(1.331)		(0.395)	(1.649)	
N		23			23			24	

Bootstrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

of the news are larger compared to the initial noisy measure of the news [3]. The results of this paper show that there is a strong negative relationship between the stock market and FFR projection changes, which is consistent with the expectations of consumers and business cutting on their spending, since the cost of capital is expected to increase in the next period.

The results for the effect of the surprise changes in PCE inflation projections are illustrated in Table 8 below. Even after extracting the surprise component of the SEP announcement, there is no effect on the asset prices and only the short-term surprise component extracted from the FFF matter. Qualitatively, the direction of an effect did not change and is still in line with the idea of the market expecting the Fed to completely offset the inflationary pressure. The effects of the unexpected component of the projections on unemployment rate, core PCE inflation and GDP growth are still statistically insignificant and are presented in the appendix table A.4.

Table 8: The effect of changes in the median PCE inflation projections (SPD)

	Current year			One year ahead			Two years ahead		
	change in PCE inflation	Surprise component	R^2	change in PCE inflation	Surprise component	R^2	change in PCE inflation	Surprise component	R^2
EUR	0.106	4.624***	0.325	0.344	4.097**	0.257	0.552	4.434***	0.297
	(0.448)	(1.501)		(0.611)	(1.658)		(0.589)	(1.420)	
CAD	0.383	4.028***	0.337	0.164	3.549**	0.247	0.353	3.879***	0.287
	(0.433)	(1.297)		(0.566)	(1.513)		(0.540)	(1.345)	
CHF	-0.0951	4.516***	0.334	0.230	3.983***	0.264	0.417	4.327***	0.307
	(0.466)	(1.448)		(0.675)	(1.474)		(0.524)	(1.156)	
GBP	0.159	3.458**	0.257	0.352	3.205*	0.205	0.449	3.309**	0.235
	(0.430)	(1.676)		(0.507)	(1.661)		(0.532)	(1.383)	
JPY	0.116	3.148***	0.206	-0.141	2.690***	0.151	0.109	2.949***	0.176
	(0.506)	(1.039)		(0.682)	(0.993)		(0.588)	(0.933)	
AUD	0.141	4.863***	0.240	0.510	4.420***	0.189	0.348	4.593***	0.206
	(0.642)	(1.818)		(1.083)	(1.599)		(0.716)	(1.757)	
NZD	0.123	5.188***	0.247	0.750	4.922**	0.211	0.468	4.948***	0.224
	(0.683)	(1.888)		(1.144)	(1.955)		(0.755)	(1.675)	
S&P500	-0.475	-2.725*	0.152	-1.019	-2.834	0.137	-1.512	-2.362	0.139
	(0.453)	(1.583)		(0.900)	(1.820)		(1.019)	(1.556)	
N		36			33			39	

Bootstrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results above show that indeed SEP could be one of the forward guidance channels through which Fed could affect the asset prices. I found that the projections for the end of the current year do not matter after dropping influential observations, and only 1- and 2- year ahead median forecasts have a significant effect on exchange rates. Importantly, the effect of 1-year ahead median FFR forecasts are larger in magnitude and the effect almost doubles after extracting the surprise component of SEP announcement. Consistent with Hakkio and Pearce (1985) there is no systematic relationship between the exchange rate and stock prices with the announcements on real economic activity.

5.3 The effects of Dispersion

Many studies have shown that monetary policy uncertainty leads to depreciation of domestic currency. Mueller, Tahbaz-Salehi and Vedolin (2017) have shown both empirically and theoretically that monetary policy uncertainty, which is present until the actual announcement of a policy leads to appreciation of foreign currencies vis-à-vis USD and thus investors should short-sell USD on announcement days [15]. There are many different ways to measure monetary policy uncertainty, and one possible way to proxy future monetary policy uncertainty is to see how different the responses of the FOMC members are regarding future state of the economy. Thus, it might be interesting to look at the effect of the variance of the Fed's dot plot for each horizon.

In order to estimate the effect of volatility and higher moments on asset prices, I use the following regression specification:

$$ln\left(S_{t+20m}\right) - ln\left(S_{t-10m}\right) = \beta_0 + \beta_1 \Delta_q {x^{FFR}}_{t,h} + \beta_2 s_t + \beta_3 \sigma_{t,h}^{FFR} + \beta_4 kurt_{t,h} + \beta_5 skew_{t,h} + \varepsilon_t, \;\; h = 0, 1, 2, \; LR$$

where $\sigma_{t,h}^{FFR}$ is the standard deviation , $kurt$ is the kurtosis and $skew$ is the skewness of the individual projections for FFR of the FOMC members for each horizon.

The results are shown in Table 9 below, and I do not present the estimations for FFR changes and the policy surprise (s_t) since they are similar to the ones presented in table 4. The effect of the standard deviation of the FOMC projections regarding target level of the FFR do not have a significant effect on the exchange rate and the stock market even after controlling for higher moments. It is only possible to calculate the measure of variance for FFR, because starting from 2016 for GDP growth, UR, and inflation instead of individual projections only summary statistics (median, central tendency, range) are published. Fed provides measures of central tendency and range on all variables, yet none of them were found to have an effect on S&P500 and FX market. This implies that the variance of the responses of FOMC members is not a good proxy of monetary policy uncertainty and other measures of monetary policy uncertainty should be considered further.

5.4 Identification-through-censoring technique

In order to extract the surprise component of the projections published in the SEP, I used the Survey of Primary Dealers and Survey of Market Participants. Using a high-frequency data already allows us to reduce the amount of noise affecting asset prices, yet there might be systematic measurement errors coming from the surveys. For example, the survey results might not measure market expectations of the news around the release time, and the actual release itself might be a noisy measure of the true factor that drives market responses. Further, the responses to the SPD or SMP generally include around 20-25

Table 9: The effect of Volatility

	Current year			One year ahead			Two years ahead		
	Std.Dev	Kurtosis	Skewness	Std.Dev	Kurtosis	Skewness	Std.Dev	Kurtosis	Skewness
EUR	-0.517	0.0232*	-0.0192	-0.251	-0.0226	0.00336	-0.00579	0.00941	0.000940
	(0.631)	(0.0116)	(0.0342)	(0.258)	(0.0252)	(0.0861)	(0.188)	(0.0175)	(0.0607)
CAD	-0.643	0.0149	0.0149	0.00340	-0.0118	0.0298	0.180	0.00640	0.0226
	(0.519)	(0.0102)	(0.0285)	(0.227)	(0.0233)	(0.0808)	(0.173)	(0.0178)	(0.0598)
CHF	-0.235	0.0242**	-0.0200	-0.116	-0.0217	0.00853	0.0110	0.00687	0.00983
	(0.558)	(0.0114)	(0.0305)	(0.227)	(0.0254)	(0.0885)	(0.195)	(0.0183)	(0.0653)
GBP	-0.513	0.0223**	-0.0156	-0.157	-0.0254	0.0285	0.0743	0.00710	0.0126
	(0.516)	(0.00905)	(0.0263)	(0.256)	(0.0231)	(0.0770)	(0.171)	(0.0169)	(0.0563)
JPY	-0.333	0.0217*	0.0101	0.119	-0.0143	0.0408	0.201	0.00314	0.0336
	(0.527)	(0.0108)	(0.0295)	(0.206)	(0.0238)	(0.0833)	(0.180)	(0.0178)	(0.0620)
AUD	-0.347	0.0316**	-0.0206	-0.0475	-0.0339	0.0666	0.113	-0.00321	0.0376
	(0.703)	(0.0150)	(0.0446)	(0.327)	(0.0384)	(0.132)	(0.275)	(0.0237)	(0.0845)
NZD	-0.120	0.0419**	-0.0442	0.0418	-0.0313	0.0333	0.0797	0.0119	0.0121
	(0.717)	(0.0154)	(0.0472)	(0.355)	(0.0380)	(0.131)	(0.287)	(0.0235)	(0.0836)
S&P500	-0.453	-0.0334*	0.106	0.431	0.0674**	0.0180	0.474	-0.00242	0.0692
	(0.979)	(0.0179)	(0.0623)	(0.378)	(0.0317)	(0.0910)	(0.296)	(0.0198)	(0.0692)
Change in median FFR		controlled			controlled			controlled	
Policy Surprise		controlled			controlled			controlled	

Bootstrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

firms, which might not be a good representation of the market responses. That is why the surprise component measured in the right-hand side of the equation 1 might be a noisy measure of the actual news. Rigobon and Sack (2008) modify the standard event-study approach to account for the possibility that the measurement of the news might contain errors [17]. Due to the classical error-in-variables (CEV) the actual response of the asset prices might be underestimated. They developed an identification-through-censoring (ITC) technique that allows to get rid of the downward bias (*attenuation bias*) and to estimate the response of asset prices to the "true" surprise measure contained in the macroeconomic news. Below I outline the main idea of the ITC technique.

The classical event study approach has the following specification:

$$\begin{aligned} R_t &= \beta s_t^* + \varepsilon_t \\ s_t^* &= \Delta x_t - E_{t-1}(\Delta x_t) \end{aligned} \tag{2}$$

where R_t is the return on an asset, in our case log changes in exchange rate, around the time of an announcement, s_t^* is the true unexpected policy announcement component calculated as the difference between the actual change Δx_t and market expectations of a change $E_{t-1}(\Delta x_t)$. Due to reasons mentioned above the observed surprise component might be the sum of the "true" surprise s_t^* and a measurement error η_t:

$$s_t = s_t^* + \eta_t$$

In that case the above specification 2 becomes

$$R_t = \beta s_t + \nu_t$$

$$\nu_t = \varepsilon_t - \beta \eta_t$$

So that the $\hat{\beta}_{OLS}$ estimator is biased downwards[4]:

$$\hat{\beta}_{OLS} = \beta - \beta \frac{\sigma_\eta^2}{\sigma_{s^*}^2 + \sigma_\eta^2}$$

In addition to underestimated β-coefficient, the R^2 will be underestimated too, so that the explanatory power of the policy surprise is downward biased. Rigobon and Sack (2008) argue that the measurement error problem is an identification problem [17]. When considering an effect of news on a single asset, we can calculate the variance of an asset, variance of the news and their covariance. But these moments are determined by 4 parameters $\{ \sigma_{s^*}^2, \sigma_\eta^2, \sigma_\varepsilon^2, \beta\}$. The ideal solution to this endogeneity issue might be using an instrumental variable approach. However, finding an instrumental variable that is correlated with the true news s_t^*, but uncorrelated with the measurement error η_t in that case is difficult, if not impossible, so authors use the method of "identification-through-censoring (ITC)".

The idea behind is that during the non-announcement days both the surprise component and the measurement error are exactly zero, which provides identification for the estimation. So we can represent the log changes in the exchange rate as follows:

$$R_t = \begin{cases} \beta s_t^* + \varepsilon_t, & t \in \{\text{Announcement days}\} \\ \varepsilon_t, & t \in \{\text{Non-announcement days}\} \end{cases}$$

where the observed news surprise contains a measurement error

$$s_t = s_t^* + \eta_t$$

The key underlying assumption is that the error term is homoskedastic, i.e σ_ε^2 is the same on announcement and non-announcement days. In this way, we can use the variance of the assets on non-announcement days as an additional identification condition. Indeed, figure 2 shows that the exchange rate volatility is higher on the event days compared to non-event days, and the identification assumption implies that this higher volatility in the currency market around 2 pm EST is due to the release of the SEP on that date.

Four moment conditions to retrieve the 4 parameters are:

$$\begin{aligned} var(R_{t-1}) &= \sigma_\varepsilon^2 \\ var(R_t) &= \beta^2 \sigma_{s^*}^2 + \sigma_\varepsilon^2 \\ var(s_t) &= \sigma_{s^*}^2 + \sigma_\varepsilon^2 \\ cov(R_t, s_t) &= \beta \sigma_{s^*}^2 \end{aligned} \tag{3}$$

By solving the above moment conditions 3 we get the Rigobon and Sack (2008) ITC estimator

$$\hat{\beta}_{ITC} = \frac{var(R_t) - var(R_{t-1})}{cov(R_t, s_t)} \tag{4}$$

The model parameters are estimated using generalized method of moments (GMM) [5] technique that minimizes the squared deviation of the errors for each moment condition in 3, and in particular I use

[4] see appendix A.2

[5] Note that the sample consists of only 25 observations, yet the properties of the GMM ae based on asymptotic behavior. Yet, Halova, Kurov, and Kucher (2014) have shown via simulation that ITC estimted parameters are similar to the population estimated values [9]

iterative GMM procedure for a given threshold until the convergence is achieved. Using an intra-day data shrinks the size of the error term ε_t, due to less noise from other market events.

As a control window, i.e for non-announcement days, I use the exchange rate and stock price changes in the previous day around the same 30 minute window, from 1:50 to 2:20 pm EST, when there were no economic announcements. And to compare the explanatory power of a simple OLS and ITC, a pseudo-R^2 can be calculated using

$$R^2 = 1 - \frac{\hat{\sigma_\varepsilon^2}}{var(R_t)}$$

where $\hat{\sigma_\varepsilon^2}$ is the variance of the disturbance estimated via GMM.

I estimate the following equation, considering only one of the surprises - the **unexpected** component of the FFR published on SEP - using both ITC and OLS techniques:

$$ln\left(S_{t+20m}\right) - ln\left(S_{t-10m}\right) = \beta \Delta_q FFR_{t,h}^{unexp} + \varepsilon_t, \quad h \; = \; 0, 1, 2, \; LR \tag{5}$$

The estimation results for ITC and OLS regressions are provided in Table 10. Now we have that even the FFR projections for the end of the current year matter for some currencies (NZD, AUD, GBP and CAD), leading to an appreciation of USD. Yet, we still have that across all currencies the 1-year ahead FFR forecasts are statistically significant, and the effect estimated via ITC is on average 2-3 times larger than that of the OLS counterpart[6]. For the S&P500 index we see that the coefficients are relatively larger in magnitude, and a surprise increase in the expected FFR leads to fall in the stock prices. Moreover, the explanatory power of the news in this 30 minute time window is larger using ITC vs OLS. These results imply that there is indeed an attenuation bias coming from a measurement error of the surprise component, and the effects of the macroeconomic news are underestimated using a standard event-study approach.

One potential concern regarding these estimates is that the identification assumption might not hold, and the variance of the error term might be different on the non-announcement day. This might be due to the fact that there might be other macroeconomic releases on that day, which increases the market volatility. However, in the results above, we saw that only news about the FFR projections matter, and in particular one-year ahead forecasts. Thus, the macroeconomic announcements regarding inflation, unemployment and GDP growth should not create excess market volatility on the announcement day. Therefore, the potential concern related to the effect of other macroeconomic news in that time frame can be relaxed.

5.5 Timing of the effect

Following Hakkio and Pearce (1985), I estimate the anticipation, announcement, and persistence effects of the news on FFR and PCE inflation. The announcement effect results are presented in the previous sections, for the 30-minute time window between 1:50 and 2:20 pm EST. To estimate the anticipation and persistence effects, I employ the same event-study framework as in 1 and the data on the changes in the exchange rate within 1-hour window before and after the announcement, which is between 12:30 - 1:30 pm EST and 2:30 - 3:30 pm EST on the day of the announcement, respectively. The surprise component extracted from the federal funds futures are calculated around the announcement

[6]The last column of table 10 presents the ration between ITC and OLS coefficients for the 1-year ahead projections. The reported R^2 for the OLS counterpart is for 1-year ahead projections, as well.

Table 10: ITC vs OLS

	ITC estimates				OLS estimates				
	H0 surprise	H1 surprise	H2 surprise	Pseudo R^2	H0 surprise	H1 surprise	H2 surprise	R^2	ITC/OLS for H1
EUR	8.742*	4.303**	6.396	.984	0.957	1.408***	0.430	0.323	3.06
	(4.947)	(1.725)	(5.256)		(0.606)	(0.267)	(0.307)		
CAD	7.216**	3.973***	7.968	.989	1.036	1.291***	0.253	0.302	3.08
	(3.438)	(1.419)	(8.178)		(0.666)	(0.347)	(0.286)		
CHF	8.161	4.225**	8.328	.981	0.874	1.216***	0.294	0.268	3.47
	(5.137)	(1.757)	(9.723)		(0.625)	(0.285)	(0.321)		
GBP	5.502**	3.203***	5.432	.957	0.993*	1.202***	0.331	0.341	2.66
	(2.321)	(1.035)	(4.396)		(0.531)	(0.281)	(0.247)		
JPY	6.565*	3.062***	6.586	.990	0.915	1.460***	0.351	0.440	2.10
	(3.470)	(0.840)	(6.103)		(0.560)	(0.249)	(0.328)		
AUD	8.389**	5.265***	8.905	.989	1.653**	1.803***	0.460	0.319	2.02
	(3.482)	(1.781)	(7.433)		(0.753)	(0.424)	(0.416)		
NZD	8.913**	5.142***	9.464	.986	1.545*	1.867***	0.469	0.335	2.75
	(3.959)	(1.662)	(8.710)		(0.847)	(0.410)	(0.418)		
S&P500	-5.461***	-3.539***	-5.480	.911	-1.199***	-1.318***	-0.515	0.350	2.69
	(1.719)	(1.008)	(3.030)		(0.418)	(0.254)	(0.343)		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

time 1:50- 2:20 pm EST. Using high-frequency data we can test whether the exchange rate market is efficient and how quickly the news is absorbed in the market. If the markets are efficient, we should expect no anticipation and persistence effects.

The table 12 below shows that there are neither anticipation nor persistence effects of the news on the changes in the FFR and PCE inflation on the exchange rate and stock prices. Apart from statistically insignificant, the magnitude of an effect is also negligible compared to the announcement effects presented in table 4. The results for GDP, unemployment rate, core PCE inflation are also found to be insignificant. Interestingly, the direction of the anticipatory effects of FFR increase are not the same across all currencies, and there is no consistency across horizons either. There is little evidence of persistence, although insignificant, we observe the same sign of an effect across all currencies so that there is still weak effect of the SEP release. These results point out that the exchange rate and stock market are efficient and absorb the available information quickly. This evidence corroborates the empirical facts presented by Hakkio and Pearce (1985) who found that exchange rates do not move in anticipation of the money surprise.

Another way of assessing the timing of Fed's information effect is to look at the changes in the exchange rate and S&P500 at 10 minute intervals 2 hours before and 3 hours after the announcement. In particular, I estimate the following equation:

$$ln(S_{t+k\cdot m}) - ln(S_{t-120m}) = \alpha + \beta_1 \Delta_q FFR^{unexp}_{t,h} + \beta_2 s_t + \varepsilon_t \tag{6}$$

with $\{h = 0, 1, 2\}$, $\{k = -110, -100, \ldots 0, \ldots, 170, 180\}$

I estimate the above equation for all seven currencies and S&P500 separately, and the independent variables are the 1-year ahead FFR forecasts and the policy surprise component derived from the FFF, since in the previous analysis it was found that only these news were important in explaining the ex-

Table 12: Anticipation and Persistence effects

	Current year				One year ahead				Two years ahead			
	FFR		PCE		FFR		PCE		FFR		PCE	
	change in median FFR	Surprise component	change in median PCE	Surprise component	change in median FFR	Surprise component	change in median PCE	Surprise component	change in median FFR	Surprise component	change in median PCE	Surprise component
EUR	-0.0149	-0.764	0.0244	-0.890	0.0785	-0.758	0.272	-1.409	0.141***	-0.903	-0.0612	-0.371
	(0.134)	(1.867)	(0.0729)	(2.414)	(0.0649)	(2.267)	(0.173)	(2.197)	(0.0540)	(2.309)	(0.508)	(2.928)
CAD	0.0317	1.367	0.0447	1.204	0.00819	1.343	0.273	0.769	0.0893	1.146	-0.0848	1.395
	(0.0807)	(1.897)	(0.0732)	(1.598)	(0.0543)	(1.632)	(0.180)	(1.681)	(0.0754)	(1.976)	(0.621)	(1.966)
CHF	-0.0269	-0.144	0.00208	-0.184	0.0519	-0.127	0.134	-0.452	0.131**	-0.251	0.0357	0.167
	(0.0682)	(2.167)	(0.0662)	(1.823)	(0.0572)	(2.139)	(0.180)	(2.679)	(0.0568)	(2.472)	(0.410)	(2.505)
GBP	-0.0528	1.265	0.0246	1.220	0.0214	1.303	0.198	0.872	0.0745	1.219	-0.383	1.739
	(0.139)	(1.535)	(0.0596)	(1.437)	(0.0794)	(1.337)	(0.178)	(1.124)	(0.0553)	(1.565)	(0.540)	(1.769)
JPY	-0.0363	1.239	-0.0230	1.309	0.0318	1.264	-0.269	1.960	-0.00647	1.322	-0.141	1.207
	(0.0469)	(2.786)	(0.0431)	(2.044)	(0.0521)	(1.995)	(0.209)	(2.335)	(0.0444)	(2.162)	(0.280)	(2.437)
AUD	-0.0549	-0.718	0.00799	-0.749	-0.00740	-0.677	0.448	-1.711	0.146	-0.883	0.0522	-0.541
	(0.111)	(2.192)	(0.138)	(2.091)	(0.0759)	(1.952)	(0.307)	(2.656)	(0.0894)	(2.415)	(0.879)	(2.701)
NZD	-0.0825	-0.670	0.0235	-0.725	0.0199	-0.609	0.346	-1.360	0.146*	-0.804	-0.170	-0.131
	(0.127)	(2.133)	(0.102)	(2.089)	(0.0771)	(2.022)	(0.247)	(3.083)	(0.0819)	(2.721)	(0.771)	(2.705)
S&P500	-0.759	0.354	-0.269	2.076	-0.429	1.040	-0.530	2.268	-0.443	1.298	-0.290	3.276
	(0.561)	(8.832)	(0.295)	(9.330)	(0.281)	(11.60)	(1.097)	(12.82)	(0.289)	(11.74)	(1.189)	(9.534)

Bootsrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	Current year				One year ahead				Two years ahead			
	FFR		PCE		FFR		PCE		FFR		PCE	
	change in median FFR	Surprise component	change in median PCE	Surprise component	change in median FFR	Surprise component	change in median PCE	Surprise component	change in median FFR	Surprise component	change in median PCE	Surprise component
EUR	0.351	14.01*	0.117	13.67**	0.0933	14.19**	-0.851	7.770	-0.0769	11.51*	-1.015	7.962
	(0.275)	(7.521)	(0.144)	(6.080)	(0.214)	(5.720)	(0.565)	(10.67)	(0.170)	(6.996)	(1.168)	(9.048)
CAD	0.228	9.866*	0.0811	9.518**	0.167	10.45*	-0.401	9.264	0.0446	8.952	-1.136*	9.232
	(0.187)	(5.600)	(0.138)	(4.771)	(0.190)	(6.101)	(0.485)	(9.900)	(0.177)	(6.341)	(0.659)	(9.125)
CHF	0.407	14.88**	0.149	15.15**	0.166	15.34**	-0.833	9.868	-0.0343	12.76	-1.024	9.166
	(0.248)	(5.906)	(0.185)	(6.029)	(0.208)	(6.698)	(0.631)	(10.25)	(0.164)	(7.802)	(1.161)	(9.807)
GBP	0.232	13.93**	0.0726	13.35**	0.0643	14.06**	-0.697	7.541	-0.0745	11.42	-1.423*	8.241
	(0.210)	(5.978)	(0.155)	(5.362)	(0.200)	(5.950)	(0.496)	(9.619)	(0.181)	(8.354)	(0.815)	(9.855)
JPY	0.303*	16.65**	0.120	17.66***	0.152	17.11**	-0.736	6.508	-0.0189	15.22**	-0.566	4.956
	(0.178)	(6.698)	(0.141)	(6.336)	(0.158)	(6.806)	(0.539)	(9.941)	(0.126)	(7.017)	(0.812)	(8.693)
AUD	0.244	20.40**	-0.0537	18.01**	0.0994	20.68**	-1.411*	10.61	-0.139	16.71*	-2.721**	10.95
	(0.271)	(8.479)	(0.243)	(7.680)	(0.262)	(8.715)	(0.779)	(14.19)	(0.255)	(9.223)	(1.173)	(11.38)
NZD	0.252	19.12***	-0.0942	16.30*	0.109	19.43**	-1.862*	10.30	-0.129	15.85*	-3.498***	11.63
	(0.375)	(7.135)	(0.269)	(9.543)	(0.314)	(7.995)	(0.962)	(13.76)	(0.203)	(8.755)	(1.334)	(12.35)
S&P500	-0.755	2.615	-0.255	0.759	-0.421	1.256	-0.499	-3.123	-0.458	-2.968	-0.473	-8.737
	(0.558)	(10.48)	(0.327)	(10.86)	(0.344)	(11.01)	(1.094)	(16.14)	(0.299)	(9.591)	(1.362)	(13.74)

Bootsrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The upper panel represents anticipation effects, while the bottom panel represents persistence effects

change rate fluctuation in 30-minute window. For all currencies I consider the period 2 hours before and 3 hours after the announcement, but for S&P500 due to its opening time between 9:30 am and 4:30 pm EST, I consider 2 hours interval around the announcement. The results for EUR, CAD, AUD & NZD are presented in figure 4, and the corresponding figure for GBP, JPY, CHF, and S&P500 is in the appendix figure A.3. Figure 4 presents β_1 and β_2 coefficients of the regression 6 with its confidence intervals for ten minute differences in the exchange rate, where the benchmark with respect to which we take the difference is 2-hours exchange rate before the meeting (12:00 pm EST).

The left and right panels of figure 4 represent β_1 and β_2 coefficients, respectively. Across all currencies there is an immediate effect of an announcement at 2pm EST, resulting in an appreciation of USD vis-à-vis foreign currencies in response to a hawkish monetary policy signals regarding the end of the next year. The effect gets stronger in the following 10 minutes and increases gradually. The response to the unexpected FFR change on average stabilizes within an hour after the announcement both for the currency and stock markets. This is true for the effect of a short-term policy surprise component extracted from the FFF. Using a slightly different methodology [7], Rosa(2011) found that the exchange rate absorbs news within 30-40 minutes, while in this case we see that on average exchange rates and the stock market take around 1-hour to absorb news about the future state of the monetary policy. This might be due to the nature of the news, because forward guidance communicated through SEP is for longer horizon, comprising the projections for the end of the next year.

[7] by looking at the evolution of the exchange rate return every 10-minute intervals instead of $\beta coefficients$[18]

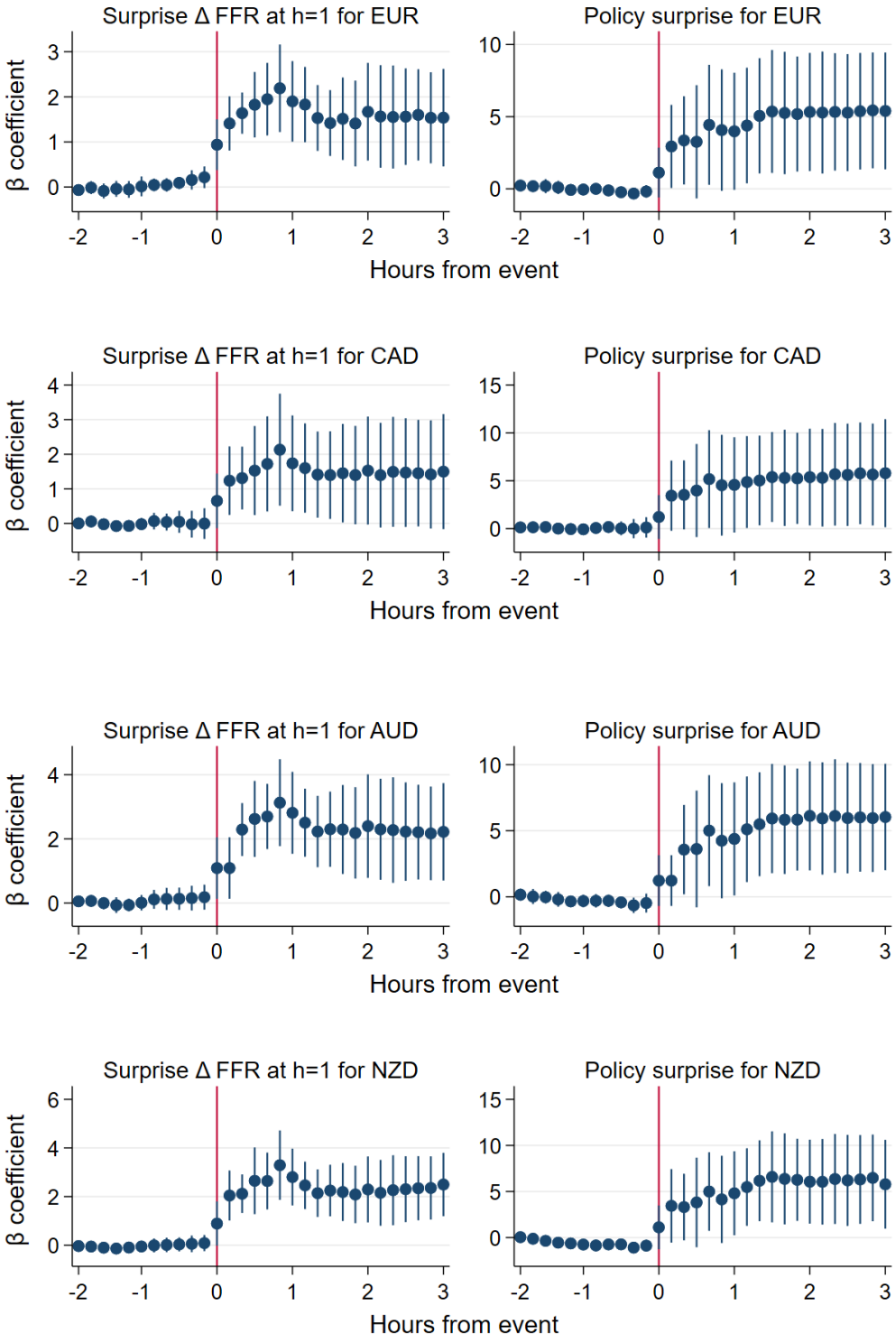

Figure 4: Timing of an effect for EUR, CAD, AUD & NZD

6 Discussion

It is interesting to compare how different asset classes respond to macroeconomic news and forward guidance. Couture (2021) examined the treasury bills and notes and found that the change in median FFR projections for the end of the current and next year affect all but the shortest end of the yield curve. Moreover, similarly to the Treasury bills, the effect of the variance of the dot plot on the exchange rate is found to be insignificant, signaling that it is not a good proxy for the monetary policy uncertainty. Differently from the Treasury bills, spot exchange rates do not respond to the changes in median FFR forecasts for the end of the current year, but this concern might be relieved since the uncertainty about these forecasts is already resolved in quarter 3 and 4 of the same year. Further, the impact of the FFR projections on exchange rate is found to be 4-5 times larger compared to Treasury bills, providing further evidence on the strong interconnectedness between exchange rates and macroeconomic fundamentals. Above analysis shows that the exchange rates react to the unexpected component of the one-year ahead FFR projections, and it was found by Couture (2021) that almost 60% of the variation in forward guidance factor [8]is explainable by this single variable. This is a strong evidence in favor of the direct effect of the macroeconomic news, and in particular forward guidance, on the currency market immediately after its release.

In standard New Keynesian model of small open economy, forward guidance is a very effective tool and the longer is the horizon of an announced interest rate changes, the larger should be an effect. There is an extensive literature on *forward guidance puzzle*, an empirical deviation of the positive relationship between horizon and magnitude of an effect[9]. In particular, Gali (2020) analyzes the effect of anticipated interest rate changes in an open economy under the assumption of Uncovered Interest Parity (UIP). In combination with UIP, allowing for the feedback effect of prices and output, the simple New Keynesian model of small open economy predicts that the effect of anticipated changes in interest rates on the exchange rate is larger, the larger is the horizon of implementation. The failure of UIP predictions in this particular dimension has been shown by Gali (2020) using monthly data for the US, UK and euro area.

Gali proposes a simple behavioral model which allows for some deviation from rational expectations. The main idea is to allow for subjective expectations in the UIP condition, i.e

$$q_t = r_t^* - r_t + \tilde{E}_t\{q_{t+1}\}$$

where q_t is the log real exchange rate, r_t (r_t^*) is the real interest rate in the home (foreign) country, and $\tilde{E}_t\{q_{t+1}\} = \alpha E_t\{q_{t+1}\}$ for $\alpha \in (0, 1)$, i.e the subjective expectations as discounted value of the rational expectations. Iterating forward,

$$q_t = \sum_{k=0}^{\infty} \alpha^k E_t\{r_{t+k}^* - r_{t+k}\}$$

In this way, we see that the effect of long-term interest rate changes is more muted compared to that of the short-term. Further, to account for the short-term overreaction of investors, he controls for the weight $\xi \geq 0$ that investors put on the exchnage rate when forming expectations about foreign assets:

$$r_t = r_t^* + \xi \tilde{E}_t\{q_{t+1}\}$$

[8]it is a measure of forward guidance developed by Swanson (2020) [19]
[9]see Gali (2020) [7], Negro, Giannoni, & Patterson (2015) [16]

Under this formulation, the news about the changes in the short-term interest rates have even larger effect, i.e

$$q_t = \frac{1}{\xi} \sum_{k=0}^{\infty} \alpha^k E_t\{r^*_{t+k} - r_{t+k}\}$$

The results of this paper are in line with the empirical evidence on *forward guidance puzzle*, since unlike the 1-year ahead projections, the unexpected component of 2-years ahead and long term projections do not matter for both stock market and the exchange rate. The simple behavioral model above by Gali (2020) could potentially explain the findings of this paper to some extent. As it was previously noted, the absence effect of the predictions for the end of the current year cannot be explained via this model, because that mainly comes from the fact that the uncertainty about these predictions are already resolved in quarter 3 and 4 of the current year.

Further, I found no effect of the median SEP announcements for FFR, UR, GDP growth and inflation on the trading volume fluctuations and bid-ask spread on the announcement days. Thus, the direct effect of the SEP release are only on the changes in the spot-exchange rate.

Since the period under consideration is 2012-2022, the analysis comprises of only around 40 observations [10] listed in the appendix table A.3. It would be interesting to collect more data from the meetings in the future to increase the predictive power of our analysis, and to examine whether there is a structural break in the effect of information conveyed via SEP due to COVID-19 pandemic or extremely high inflationary period that is occurring now. Due to limited data, it is not possible to perform this analysis at this stage.

[10] even less for the survey data (SPD, SMP)

7 Conclusion

This paper examines the response of the spot exchange rate and stock prices within a 30-minute window to economic news related to future monetary policy path released quarterly after each FOMC meeting. I use intraday data on 7 foreign currencies vis-à-vis USD, and for comparison I also employ high-frequency data on S&P500 for the period of 2012-2022. Two types of economic news are considered: i) Summary of Economic Projections which includes federal funds rate, GDP growth, inflation and unemployment rate forecasts ii) the short-term policy surprise component extracted from federal funds futures.

On average, exchange rate volatility and trading volume fluctuations tend to be higher on FOMC announcement days compared to non-announcement days, providing an initial evidence of an effect. In order to retrieve the unexpected component of the announcements, Survey of Primary Dealers data is used. There are three main findings of this paper. First, on average USD appreciates by 36 bp vis-à-vis foreign currencies in response to an unexpected 25 bp increase in the median target federal funds rate projections for the end of the next year. Second, there is no evidence of anticipation or persistence effects, and the exchange rate and stock market react immediately to the information contained in SEP and tend to absorb the news within an hour after the release. This analysis on timing of an effect provides an evidence in favor of the efficiency of the exchange market. Third, using an identification-through-censoring technique that accounts for the possible measurement errors in the survey data, I found that the event study approach underestimates the impact of the FFR target level forecasts on the exchange rate.

Although in the literature monetary policy uncertainty is a significant determinant of the exchange rate, I found that the volatility the Fed's dot plot and the range do not have any effect on the currency and stock market, implying that they are not a good proxy for monetary uncertainty. There is no evidence about the impact of median, range and central tendency of PCE inflation, GDP growth, unemployment rate forecasts on the currency and stock markets. The results indicate that SEP could be one of the forward guidance channels of the Fed, and the main factor that influences short-term exchange rates is the median FFR projections. Given that the market reacts to these news contained in SEP, from a policy perspective, it might be useful to have SEP forecasts or at least long-term FFR forecasts after each FOMC meeting, not only at a quarterly frequency, providing the market with more information.

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Appendices

A.1 Sample of SPD questions

1.b *What are your expectations for the most likely levels of the medians of FOMC participants' target federal funds rate projections in the SEP? Please provide your responses out to three decimal places.* [11]

Table A.1: Sample of a table for responses

	Year-end 2022	Year-end 2023	Year-end 2024	Long-run
December SEP median	0.875%	1.625%	2.125 %	2.500%
March SEP median	-	-	-	-

9.a *Provide your estimate of the most likely outcome for output, inflation, and unemployment.*

Table A.2: Sample of a table for responses

	Real GDP (Q4/Q4 growth)	Core PCE inflation (Q4/Q4)	Headline PCE Inflation (Q4/Q4)	Unemployment rate (Q4 average level)
2022	-	-	-	-
2023	-	-	-	-
2024	-	-	-	-
Long-run	-	-	-	-

A.2 Classical error-in-variables

The derivation of downward biased $\hat{\beta}_{OLS}$:

$$plim\hat{\beta}_{OLS} = \frac{Cov(R_t, s_t)}{Var(s_t)} = \frac{Cov(\beta_0 + \beta_1 s_t + \varepsilon_t - \beta_1\eta_t, s_t)}{Var(s_t)} = \frac{\beta_1 Var(s_t) - \beta_1 Cov(s_t, \eta_t)}{Var(s_t)} = \beta_1 - \beta_1\frac{\sigma_\eta^2}{Var(s_t)}$$

where

$$Var(s_t) = Var(s_t^* + \eta_t) = \sigma_{s_t^*}^2 + \sigma_\eta^2$$

So,

$$\hat{\beta}_{OLS} = \beta_1 - \beta_1\frac{\sigma_\eta^2}{\sigma_{s_t^*}^2 + \sigma_\eta^2}$$

[11] this question was also included in the Survey of Market Participants

Table A.3: FOMC announcement dates

Year	Date	Target federal funds rate
2012	January 25	0.25
	April 25	0.25
	June 20	0.25
	September 13	0.25
	December 12	0.25
2013	March 20	0.25
	June 19	0.25
	September 18	0.25
	December 18	0.25
2014	March 19	0.25
	June 18	0.25
	September 17	0.25
	December 17	0.25
2015	March 18	0.25
	June 17	0.25
	September 17	0.25
	December 16	0.50
2016	March 16	0.50
	June 15	0.50
	September 21	0.50
	December 14	0.75
2017	March 15	1.00
	June 14	1.25
	September 20	1.25
	December 13	1.50
2018	March 21	1.75
	June 13	2.00
	September 26	2.25
	December 19	2.50
2019	March 20	2.50
	June 19	2.50
	September 18	2.00
	December 11	1.75
2020	March 18	cancelled
	June 10	0.25
	September 16	0.25
	December 16	0.25
2021	March 17	0.25
	June 16	0.25
	September 22	0.25
	December 15	0.25
2022	March 22	0.5

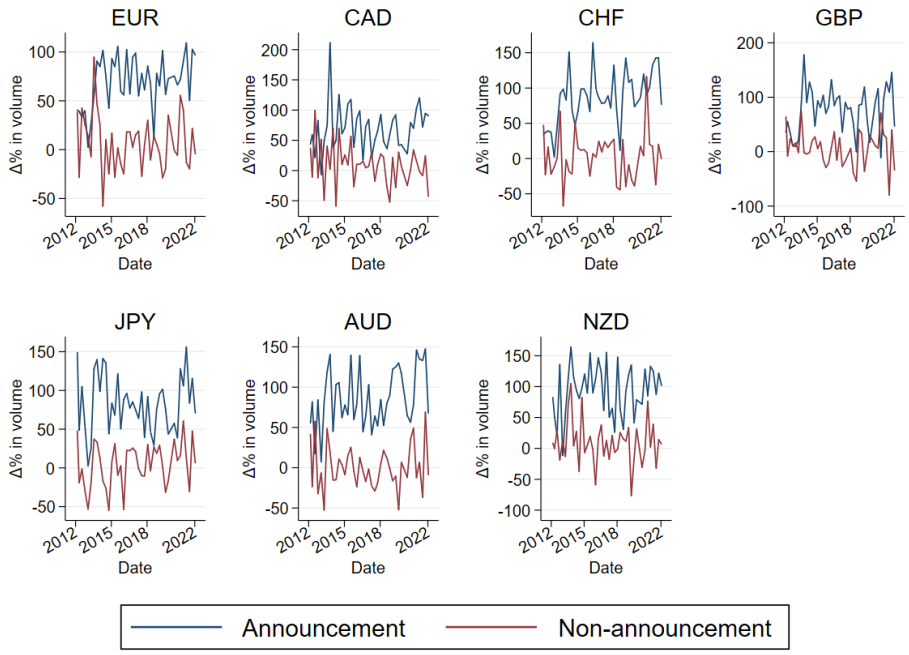

Figure A.1: Changes in Trading Volume

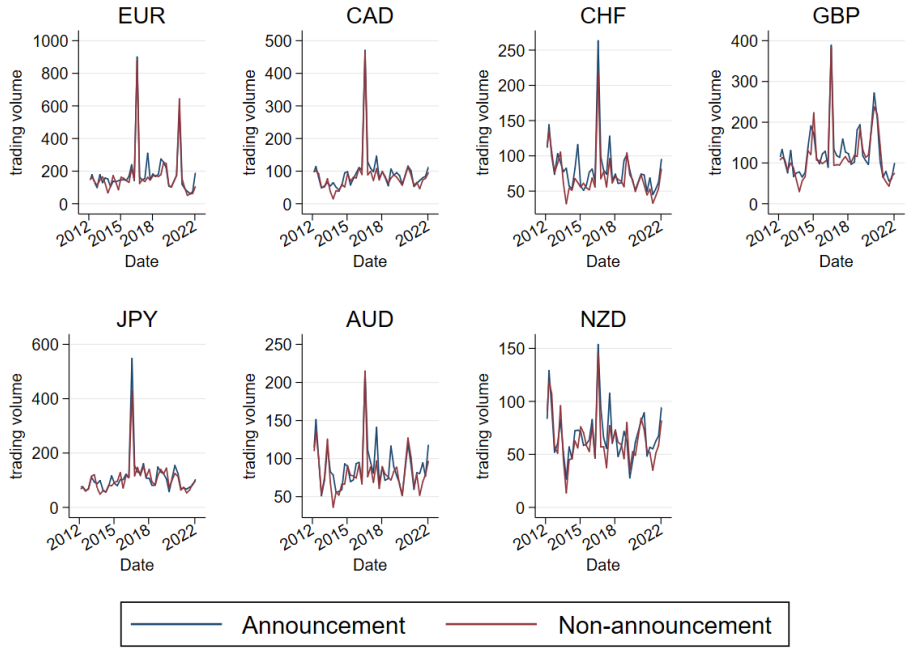

Figure A.2: Average trading Volume

Table A.4: GDP growth, UR and core PCE inflation(SPD)

	Current year			One year ahead			Two years ahead		
	GDP	Unemployment rate	core PCE inflation	GDP	Unemployment rate	core PCE inflation	GDP	Unemployment rate	core PCE inflation
EUR	0.0306	0.0124	-0.0597	0.136	0.0214	0.0852	-0.200	-0.0133	0.569
	(0.0520)	(0.328)	(0.459)	(0.202)	(0.213)	(0.527)	(0.241)	(0.213)	(0.506)
CAD	0.0289	0.157	-0.148	0.0598	0.113	0.0260	-0.152	0.0476	0.598
	(0.0497)	(0.264)	(0.367)	(0.183)	(0.240)	(0.333)	(0.204)	(0.197)	(0.402)
CHF	0.0156	0.00412	-0.144	0.130	-0.0256	0.0737	-0.108	0.00741	0.846
	(0.0835)	(0.296)	(0.420)	(0.205)	(0.220)	(0.369)	(0.193)	(0.199)	(0.549)
GBP	0.0197	-0.0179	-0.115	0.175	-0.0562	0.0865	-0.0963	-0.0504	0.437
	(0.0697)	(0.236)	(0.369)	(0.216)	(0.227)	(0.453)	(0.167)	(0.170)	(0.375)
JPY	0.00965	-0.0745	-0.103	0.104	-0.125	0.0345	-0.141	0.0361	0.665
	(0.0466)	(0.317)	(0.360)	(0.160)	(0.238)	(0.402)	(0.177)	(0.198)	(0.544)
AUD	0.0382	0.0287	-0.0909	0.0739	0.0450	0.168	-0.249	0.0186	0.880
	(0.0716)	(0.422)	(0.534)	(0.295)	(0.363)	(0.730)	(0.259)	(0.286)	(0.632)
NZD	0.0277	-0.0356	-0.00640	0.0854	-0.0139	0.168	-0.276	0.0391	0.907
	(0.0925)	(0.332)	(0.489)	(0.362)	(0.341)	(0.724)	(0.274)	(0.251)	(0.745)
S&P500	-0.0315	0.157	-0.592	-0.277	0.225	-1.755***	0.278	0.105	-1.186
	(0.0549)	(0.537)	(0.727)	(0.297)	(0.429)	(0.646)	(0.285)	(0.368)	(1.546)
N		39			39			39	

Bootstrapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

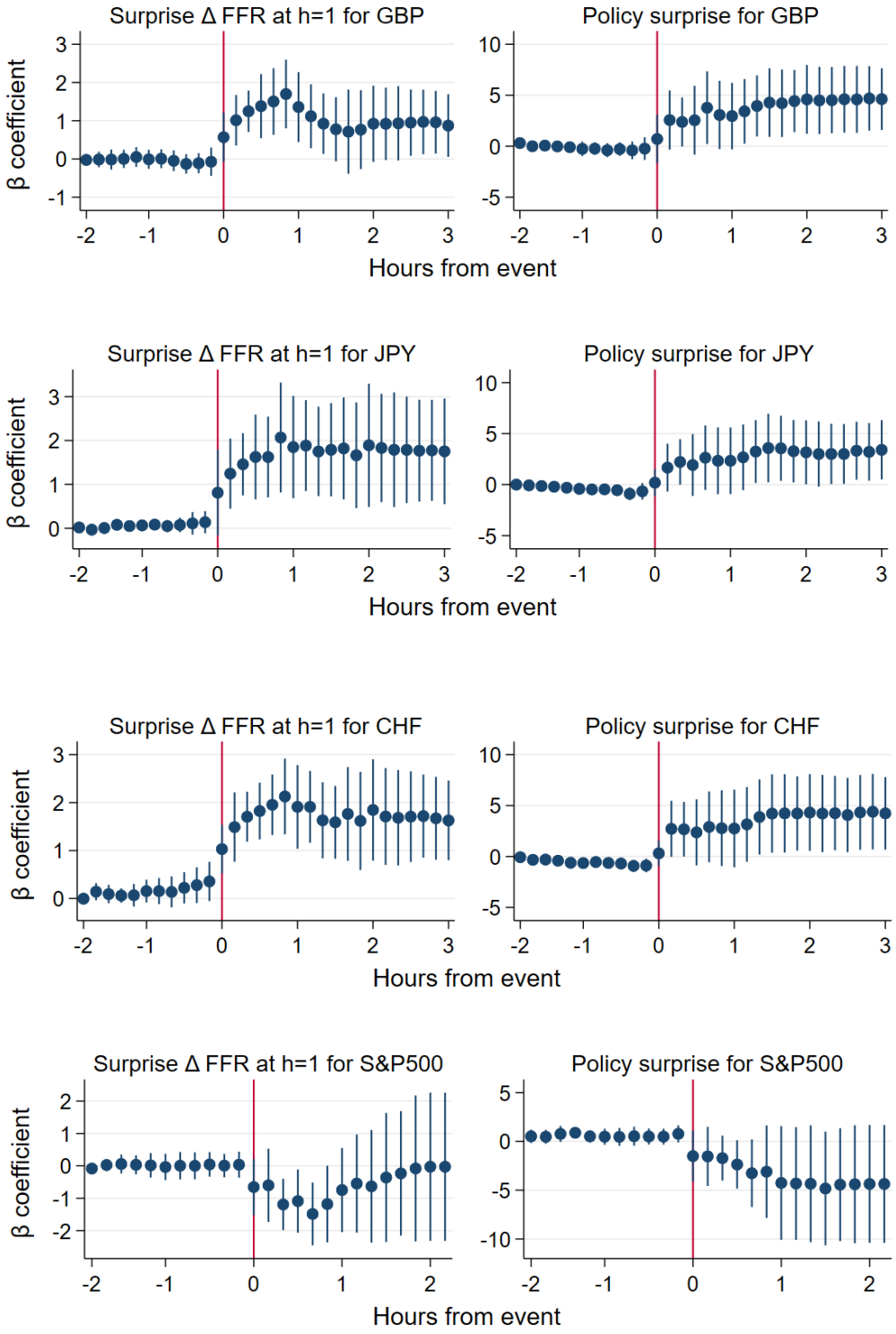

Figure A.3: Timing of an effect for GBP, JPY, CHF, & S&P500