

Real-time Price Discovery via Verbal Communication: Method and Application to FedSpeak

Roberto Gómez Cram, and Marco Grotteria

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Previous literature

- Expectations play an important role for central banks
 - Forward-guidance is a key tool used to shape expectations
- How do economic agents form expectations?
 - Large macroeconomic literature on information rigidity
(e.g., Mankiw and Reis, 2002; Reis, 2006; Coibion and Gorodnichenko, 2015)

This paper

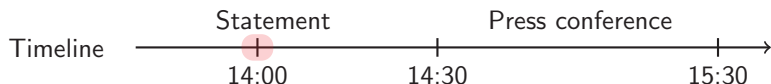
- Provides granular evidence on the agents' expectations formation process.
- Investors' fail to fully incorporate the Central Banks' messages
 - This failure is economically large.

Identifying individual messages

- For the days in which the Federal Open Market Committee has a scheduled meeting,
 - ① we scrape the videos of the Fed Chairman's press conference
 - ② we split the video into smaller frames of around 3 seconds each
 - ③ we use an end-to-end deep learning algorithm to convert the audio into interpretable text
 - ④ we timestamp each word spoken in each moment
 - ⑤ we align high-frequency financial data with these exact words
- ⇒ link between specific messages sent and the signals received

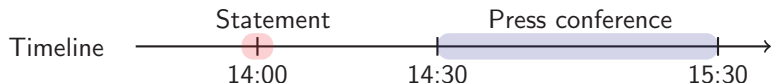


Start time	End time	Text	Fed Chairman/News outlet
14:35:36.286	14:35:39.946	Per your statement here, I guess the question is,	New York Times
⋮	⋮	⋮	⋮
14:37:05.586	14:37:07.696	we're thinking of it as essentially in the nature	Powell
14:37:07.696	14:37:09.526	of a midcycle adjustment to policy.	Powell
⋮	⋮	⋮	⋮
14:45:09.906	14:45:12.716	Where is that bar right now, because I think there's	Wall Street Journal
14:45:12.716	14:45:15.546	some confusion about how the Committee is responding.	Wall Street Journal
14:45:16.796	14:45:21.686	Yes. So we, as we noted—we noted at the bottom	Powell
14:45:21.946	14:45:24.226	of the statement that language, which really says how we're thinking about it.	Powell
⋮	⋮	⋮	⋮
14:48:05.296	14:48:08.286	You called it "a midcycle adjustment to policy."	Reuters
14:48:08.766	14:48:11.356	And, I mean, what should we take this to mean,	Reuters



How the July Statement Changed From June

- The Committee decided to lower the target range for the federal funds rate to 2 to 2-1/4 percent (from 2-1/4 to 2-1/2).
- The statement included a new sentence:
about this outlook have increased. In light of these uncertainties and muted inflation pressures, the Committee will closely remain. As the Committee contemplates the future path of the target range for the federal funds rate, it will continue to monitor the implications of incoming information for the economic outlook and will act as appropriate to sustain the expansion, with a strong labor market and inflation near its symmetric 2 percent objective.
- We identify the sentences added/removed between consecutive statements and search for these sentences in the press conference

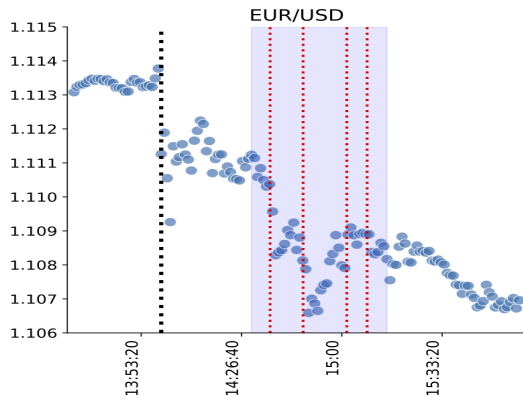


Chair Powell's Press Conference

- Powell was assaulted by questions on the meaning of this change

Start time	End time	Text	Fed Chairman/News outlet
14:35:36.286	14:35:39.946	Per your statement here, I guess the question is,	New York Times
:	:	:	:
14:37:05.586	14:37:07.696	we're thinking of it as essentially in the nature	Powell
14:37:07.696	14:37:09.526	of a midcycle adjustment to policy .	Powell
:	:	:	:
14:45:09.906	14:45:12.716	Where is that bar right now, because I think there's	Wall Street Journal
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14:45:21.946	14:45:24.226	of the statement that language, which really says how we're thinking about it.	Powell
:	:	:	:
14:48:05.296	14:48:08.286	You called it " a midcycle adjustment to policy ."	Reuters
14:48:08.766	14:48:11.356	And, I mean, <i>what should we take this to mean</i> ,	Reuters

The red dotted lines: Powell mentioned “midcycle adjustment to policy.”



The message → signaled that there is no plan for a series of rate cuts

- When the Chairman discusses changes between consecutive statements:
 - ① Price volatility and trading volume spike dramatically
 - ② Prices move in the same direction as they did around the statement release
- Strong positive correlation between price changes around the statement release and the subsequent press conference
 - For example: 40% for medium-term Eurodollar futures or 44% for SPY
- We assess the economic magnitude of our findings via a trading strategy.
- What can explain our findings?
 - Consistent with canonical models of information rigidities.
 - Some investors underreact to Central Banks' messages.
 - We reject six alternative explanations

Statement vs. Press Conference

- Let x_t be the latent state of monetary policy at time t :

$$x_t = \rho x_{t-1} + \nu_t$$

- Unit mass of atomistic agents, cannot observe x_t , but observe $y_{i,t}$

$$y_{i,t} = x_t + \omega_{i,t}$$

- Each agent translates the Fed Chairman's words into private signals $y_{i,t}$
- $\omega_{i,t}$ is i.i.d. both across time and agent
- Agents know the process for x_t and its parameter values
- Each agent updates their estimates optimally:

$$F_{i,t}x_t = F_{i,t-1}x_t + G(y_{i,t} - F_{i,t-1}x_t) \quad (1)$$

- G is the steady-state Kalman filter gain.
- If $G = 1 \implies$ signal is fully revealing

- Assuming noisy signals, then forecast revisions are autocorrelated

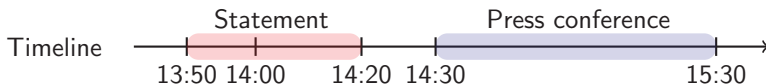
$$E_{t-1}[F_t x_{t+h} - F_{t-1} x_{t+h}] = \underbrace{\lambda}_{1-G} (F_{t-1} x_{t+h} - F_{t-2} x_{t+h})$$

⇒ testable predictions that are independent of the process underlying x .

- Measuring information rigidities via the parameter λ in

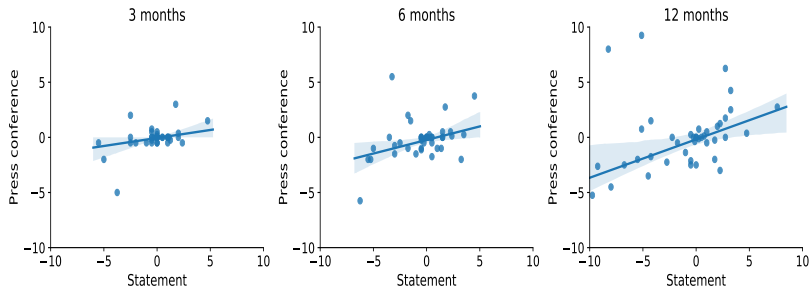
$$\underbrace{F_t x_{t+h} - F_{t-1} x_{t+h}}_{\Delta p_{PC}} = a + \lambda \underbrace{(F_{t-1} x_{t+h} - F_{t-2} x_{t+h})}_{\Delta p_{ST}} + \epsilon_t$$

- Δp_{ST} & Δp_{PC} are price changes around two windows:



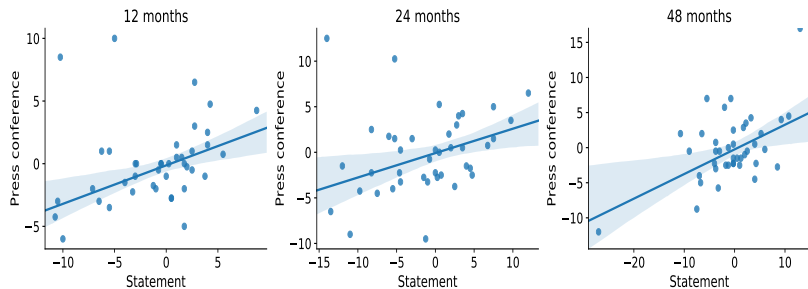
- If Fed words are fully revealing:

- $\lambda = 1 - G = 0$: Prices should include all information at 14:30



Strong relationship between price changes around the ST and PC

Summary statistics



We group asset i into bucket k and run a pooled OLS:

$$\underbrace{\Delta p_{it,PC}}_{\Delta p \text{ at press conference: e.g. 14:30-15:30}} = a_k + \lambda_k \underbrace{\Delta p_{it,ST}}_{\Delta p \text{ around statement: 13:50-14:20}} + \epsilon_{it}$$

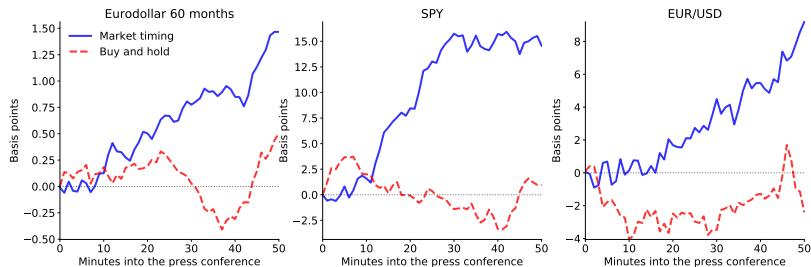
	Fed funds futures		Eurodollar Futures		Stocks	Forex
	1m-6m	9m-15m	6m-12m	24m-70m		
a	-0.01	0.11	0.16	0.10	-3.32	-5.40
	[-0.03]	[0.48]	[0.36]	[0.23]	[-0.39]	[-1.57]
λ	0.21	0.19	0.19	0.27	0.36	0.27
	[1.44]	[1.95]	[2.08]	[3.29]	[2.24]	[3.61]
R^2	2.69	6.86	3.17	15.84	10.73	13.13

- We quantify in monetary terms the value of information rigidity.
- A simple trading strategy that conditions on the statement news:
 - At the start of the press conference
 - Go long if $\Delta p_{t,ST} > 0$
 - Short (or stay out) if $\Delta p_{t,ST} < 0$
 - Close the position at the end of the press conference
 - Does not require any parameter estimation!

We run $r_{it,MT} = \alpha_k + \beta_k r_{it,B} + \epsilon_{it}$ and look at α_k

	Fed funds futures		Eurodollar Futures		Stocks	Forex
	1m-6m	9m-15m	6m-12m	24m-70m		
α	0.37	0.40	1.16	1.02	12.66	8.14
	[1.27]	[1.65]	[2.80]	[2.11]	[2.30]	[2.57]
β	0.54	0.33	0.32	0.08	-0.13	0.18
	[2.40]	[2.53]	[2.68]	[0.42]	[-0.61]	[1.12]
R^2	9.84	17.79	4.38	0.89	1.69	3.39

Average cumulative performance within the press conference



- Each bp move in the Eurodollar futures contract → \$25 per contract
- Over-performance approx. starts in minute 10 → start of the Q&A section

Within press-conference analysis

Conjecture

- Statement-related minutes, D_t , are the only moments (wlog) in which investors update their beliefs about the Fed's message.

Testable implications during statement-related minutes: D_t

- 1 investors updated their beliefs and trade accordingly
- 2 forecasts revisions $F_t X_{t+h}$ move more
- 3 forecasts revisions move in the same direction as in the statement

Statement-related minutes dummy variable D_t :

- ① We aggregate the 3-second level text in to 1-minute frequency.
- ② We run a part-of-speech analysis of the **statement news** to obtain for each sentence the nouns, adjectives, verbs.
- ③ We search for these nouns, adjectives, verbs (and their synonyms) in the subsequent press conference.
- ④ We add the requirement that the same sentence contains the word “statement”.

Output:

$\implies D_t$ equals 1 when (1), (2), (3), and (4) are satisfied, 0 otherwise

In *Statement-related minutes*:

- 1 Price volatility increases significantly
 - For medium-term Eurodollars, stocks and forex the price variation is about 14% larger than the other minutes.
- 2 Trading volume increases significantly
 - For EU futures between 24m- 70m is 17% larger
 - For FF futures above 9 months is 50% larger
- 3 Prices move on average in the same direction as their initial reaction around the statement release

We group asset i into bucket k and run a pooled OLS:

$$\Delta p_{it} = \begin{cases} a_k^- + b_k^- D_{t-1} + \epsilon_{it}, & \text{if } \Delta p_{ij,ST} < 0; \\ a_k^+ + b_k^+ D_{t-1} + \epsilon_{it}, & \text{if } \Delta p_{ij,ST} > 0, \end{cases}$$

- The simple model predicts $b^- < 0$ & $b^+ > 0$

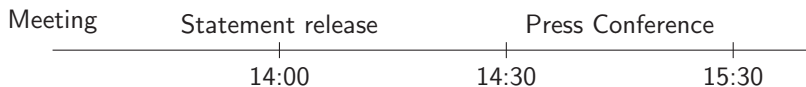
3. Return variation conditioning on statement news

	Fed funds futures		Eurodollar futures		Stocks	Forex
	1m-6m	9m-15m	6m-12m	24m-70m		
<i>Days when statement shock was negative</i>						
a^-	-0.01	-0.01	-0.01	-0.02	-0.27	-0.17
	[-2.24]	[-0.98]	[-1.37]	[-2.52]	[-1.54]	[-1.89]
b^-	0.00	-0.03	-0.02	-0.08	-1.82	-0.55
	[0.22]	[-1.31]	[-0.52]	[-2.17]	[-2.80]	[-1.86]
<i>Days when statement shock was positive</i>						
a^+	0.00	0.00	0.00	0.02	0.27	0.08
	[0.43]	[0.80]	[0.15]	[1.84]	[3.31]	[0.94]
b^+	-0.00	0.01	0.05	0.04	0.58	0.22
	[-0.12]	[0.53]	[2.26]	[1.04]	[1.92]	[0.56]

- We study how Central Bank's communication shapes investors' expectations
- We align with a minute-level accuracy the Chairman's words with financial asset prices.
- We advance the hypothesis and establish empirically that investors' expectations gradually incorporate the Fed's messages.
- We also quantify in monetary terms the value of this information rigidity.

Appendix

- The Federal Open Market Committee (FOMC) schedules eight meetings per year
- The FOMC issues a policy statement following each meeting
- The Chairman holds a press briefing after each FOMC meeting to discuss the FOMC's policy decisions and to provide context.



Change in price in ST or PC time interval – Δp	Event	Fed Funds Futures			Eurodollar Futures			Stocks	Forex
		All	1m-6m	9m-15m	All	6m-12m	24m-70m		
Mean (bps)	Statement	-0.58	-0.19	-0.97	-0.67	-0.68	-0.67	17.35	5.78
	Press Conference	-0.04	-0.08	-0.01	-0.08	-0.07	-0.08	2.99	-3.68
Standard Deviation (bps)	Statement	2.96	2.00	3.92	5.37	3.73	6.03	46.32	39.75
	Press Conference	2.00	1.08	2.92	3.90	2.24	4.57	50.97	30.21
Mean absolute value (bps)	Statement	2.12	1.30	2.94	3.86	2.70	4.32	36.31	30.69
	Press Conference	1.25	0.56	1.95	2.72	1.42	3.24	37.42	23.76

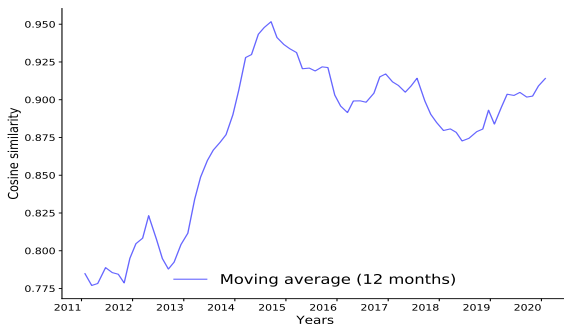
Minute-level returns

Absolute minute-level variation-ratio	PC/ST	0.898	0.804	0.992	0.982	0.971	0.993	1.850	3.531
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We report mean values across security buckets

$$\text{Absolute minute-level variation-ratio} = \frac{\sum_i |r_i^{PC}|}{\sum_i |r_i^{ST}|}$$

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The cosine similarity between two FOMC statements is the number of attributes (term-frequency) shared by both documents divided by the average of the number of attributes possessed by each document.

	All	Fed Funds Futures			Eurodollar Futures		
		All	1m-6m	9m-15m	All	6m-12m	24m-70m
<i>a</i>	-0.04	0.16	0.16	0.15	-0.15	-0.04	-0.18
	[-0.19]	[1.94]	[2.17]	[2.15]	[-0.55]	[-0.16]	[-0.70]
<i>b</i>	0.04	0.05	0.08	0.05	0.04	0.01	0.04
	[0.34]	[1.17]	[1.49]	[1.19]	[0.29]	[0.16]	[0.33]
R^2	0.45	0.81	0.35	1.30	0.39	0.01	0.55

Standard errors are double clustered at date-asset level. t-stats in brackets.

$$\underbrace{\Delta p_{i,t+1 \rightarrow t+2}}_{\Delta p \text{ at non press conference dates: e.g. 14:30-15:30}} = a + b \underbrace{\Delta p_{i,t-1 \rightarrow t}}_{\Delta p \text{ around statement: 13:50-14:20}} + \epsilon_{i,t+1},$$

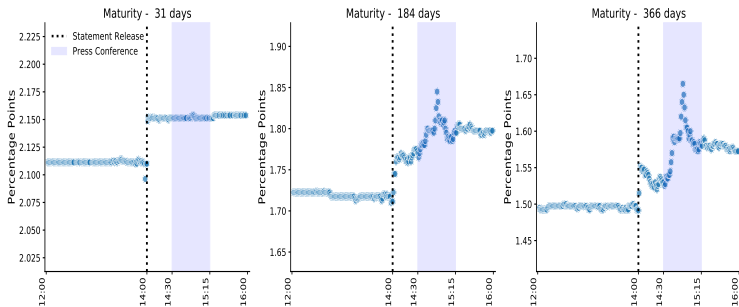
	Negations	Comparisons	Numbers	Insight	Relativity	Motion	Time	Past	Present	Future
<i>a</i>	0.97	2.48	1.66	2.30	11.84	1.92	3.50	2.43	16.9	1.69
	[46.68]	[71.65]	[30.68]	[67.73]	[141.97]	[63.59]	[70.57]	[59.88]	[146.14]	[53.92]
<i>b</i>	-0.16	0.24	0.31	0.42	1.65	0.38	1.15	-0.15	-1.93	0.37
	[-2.26]	[2.02]	[1.62]	[3.52]	[5.7]	[3.65]	[6.65]	[-1.05]	[-4.8]	[3.42]

The Table reports the regression estimates for the following Equation:

$$\text{Freq}_{it} = a + bD_t + \epsilon_{it},$$

where Freq_{it} is the frequency value for words in category i in minute t , and D_t is the dummy variable. The search words are categorized into language categories following the Linguistic Inquiry and Word Count (LIWC)

Rate cut smaller than the market expected



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[...] As the Committee contemplates the future path of the target range for the federal funds rate, it In light of these uncertainties and muted inflation pressures, the Committee will monitor the implications of incoming information for the economic outlook and will act as appropriate to sustain the expansion, with a strong labor market and inflation near its symmetric 2 percent objective. In determining the timing and size of future adjustments to the target range for the federal funds rate, the Committee will assess realized and expected economic conditions relative to its maximum employment objective and its symmetric 2 percent inflation objective. This assessment will take into account a wide range of information, including measures of labor market conditions, indicators of inflation pressures and inflation expectations, and readings on financial and international developments. [...]

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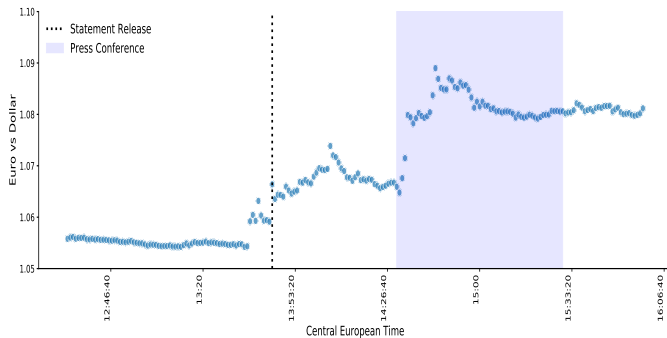
Jeanna Smialek: “Per your **statement**, I guess the question is, is there any reason to believe that a 25 basis point cut is going to be sufficient to expediently return inflation to your 2 percent target? And, if not, what are you going to be looking at to convince you that you need to cut rates again? What is the hurdle rate there?”

Chairman: “We’re contemplating the future path of the target range for the federal funds rate. [...] We are thinking of it as a [...] midcycle adjustment to policy.” [◀ Go Back](#)

- In the Bloomberg FOMC blog, one minute after it was written that the “*mid-cycle adjustment*” comment signals there is no plan for a series of rate cuts.”

- We use 5 European stock indices and 6 major currencies against EUR
 - Stocks: Europe 50, UK 100, Germany 30, France 40, Spain 35.
 - Forex: EUR vs. USD, GBP, JPY, CHF, AUD, CAD.

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	All	Stocks	Forex
a	-5.67	-5.15	-7.24
	[-1.77]	[-0.53]	[-1.09]
b	0.95	1.25	0.78
	[2.80]	[2.39]	[2.40]
R^2	13.83	13.46	15.73

Standard errors are double clustered at date-asset level. t-stats in brackets.

$$\underbrace{\Delta p_{i,t+1 \rightarrow t+2}}_{\Delta p \text{ at press conference: 14:30-15:30}} = a + b \underbrace{\Delta p_{i,t-1 \rightarrow t}}_{\Delta p \text{ around statement: 13:35-14:05}} + \epsilon_{i,t+1},$$