Online Appendix to: Monetary Policy Communication Shocks and the Macroeconomy

Robert Goodhead* and Benedikt Kolb†

17th July 2022

1 Details on the Federal Funds Futures and FOMC Schedule

1.1 Additional Details on the Federal Funds Futures

Assumption of constant risk premium on meeting days. Under the assumption of efficient markets, the futures rate $f_{d,t}^{(m)}$ reflects the market expectations of the average effective federal funds rate $\bar{r}_{t+m}$:

$$f_{d,t}^{(m)} = \mathbb{E}_{d,t}[\bar{r}_{t+m}] + \delta_{d,t}^{(m)}, \ \forall m \geq 0,$$

where $\delta_{d,t}^{(m)}$ is a risk-premium term. Since Kuttner (2001), many authors have argued that the movements in the federal funds futures market observed on FOMC meeting days capture a surprise component of monetary policy. We assume no change in the risk-premium $\delta_{d,t}^{(m)}$ for that short time window.

1.2 Details Regarding FOMC Meeting Days

A potential limitation of our focus on scheduled meetings is the possibility of rate changes during unscheduled meetings (see also Gürkaynak, 2005). The FOMC can deviate from its published meeting schedule if circumstances require it and has done so several times in our sample, as documented below. If markets were to incorporate an endogenous probability of unscheduled meetings into their pricing, this could be problematic for our identification scheme. However, given that we rely on futures rate changes on meeting days, the occurrence of unscheduled meetings will only bias our shock measures if the market expectations about the likelihood of an unscheduled meeting are changed *during the day* of the previous (scheduled) FOMC meeting. In the following, we report some details on those FOMC announcements we do not consider to be scheduled (and therefore do not use in our analysis). We also compare these to the Appendix 2 of the working paper version of Gürkaynak et al. (2005) (Gürkaynak et al, 2004; GSSWP in the following), which contains a detailed summary (up to May 2004). It becomes clear that the committee has never hinted at unscheduled meetings during the preceding meetings. Therefore, we do not believe the effect of unscheduled meetings presents a serious concern.

4/18/1994. Unscheduled conference call; from the minutes from March 22, 1994: "It was agreed that the next meeting of the Committee would be held on Tuesday, May 17, 1994."[1] GSSWP lists this date as an "intermeeting move".

*Corresponding author. Central Bank of Ireland. New Wapping Street, North Wall Quay, Dublin 1, D01 F7X3, Ireland. Tel.: +353 1 224 4655. Email: robert.goodhead@centralbank.ie.

†Deutsche Bundesbank. Wilhelm-Epstein-Strasse 14, D-60431 Frankfurt/Main, Germany. Tel.: +49 69 9566 5755. Email: benedikt.kolb@bundesbank.de.

[1] https://www.federalreserve.gov/fomc/MINUTES/1994/19940322min.htm

10/15/1998. Unscheduled conference call. From the meeting statement of the previous meeting on Sept. 29th, it is not fully clear whether the meeting was scheduled: "In a telephone conference held on October 15, 1998, the Committee members discussed recent economic and financial developments and their implications for monetary policy. (...) At the conclusion of this discussion, the Chairman indicated that he would instruct the Federal Reserve Bank of New York to lower the intended federal funds rate by 25 basis points, consistent with the Committee's directive issued at the meeting on September 29, 1998. It was agreed that the next meeting of the Committee would be held on Tuesday, November 17, 1998."[2] However, we choose not to consider this date as GSSWP declare it an "intermeeting move".

1/3/2001. Unscheduled conference call. From the December 19th (2000) FOMC minutes: "This meeting adjourned at 1:35 p.m. with the understanding that the next regularly scheduled meeting of the Committee would be held on Tuesday-Wednesday, January 30-31, 2001."[3]

4/18/2001. Unscheduled conference call. From the March 20th FOMC minutes: "It was agreed that the next meeting of the Committee would be held on Tuesday, May 15, 2001."[4] GSSWP: "intermeeting move".

9/17/2001. Unscheduled conference call. From the August 21st FOMC minutes: "It was agreed that the next meeting of the Committee would be held on Tuesday, October 2, 2001." GSSWP: "intermeeting move".[5]

8/10/2007 and 8/17/2007. Both dates were unscheduled conference calls. From the August 7th FOMC minutes: "It was agreed that the next meeting of the Committee would be held on Tuesday, September 18, 2007."[6]

1/9/2008 and 1/22/2008. Unscheduled conference call on the 9th and 22nd, but meeting on the 30th was scheduled. From the Dec. 11th, 2007 FOMC minutes: "It was agreed that the next meeting of the Committee would be held on Tuesday-Wednesday, January 29-30, 2008."[7]

3/11/2008. Meeting on the 18th, unscheduled conference call on the 11th. From the Jan. 30th FOMC minutes: "It was agreed that the next meeting of the Committee would be held on Tuesday, March 18, 2008."[8]

10/08/2008. Meeting on the 29th, unscheduled conference call on the 7th. From the Sept. 16th FOMC minutes: "It was agreed that the next meeting of the Committee would be held on Tuesday-Wednesday, October 28-29, 2008."[9]

2 Further Results and Robustness Checks

2.1 Purging Coefficients

The Greenbook projections are created prior to each FOMC decision by the staff of the Federal Reserve Board of Governors. Forecasted variables include real GDP growth, the growth in the GDP price deflator,

[2] https://www.federalreserve.gov/monetarypolicy/fomchistorical1998.htm
[3] https://www.federalreserve.gov/fomc/minutes/20001219.htm
[4] https://www.federalreserve.gov/fomc/minutes/20010320.htm
[5] https://www.federalreserve.gov/fomc/minutes/20010821.htm
[6] https://www.federalreserve.gov/fomc/minutes/20070807.htm
[7] https://www.federalreserve.gov/monetarypolicy/fomcminutes20071211.htm
[8] https://www.federalreserve.gov/monetarypolicy/fomcminutes20080130.htm
[9] https://www.federalreserve.gov/monetarypolicy/fomcminutes20080916.htm

the unemployment rate, and several other important macroeconomic variables. We downloaded Fed Greenbook data from the dataset maintained by the Philadelphia Fed.[10]

The Blue Chip forecasts are made by a group of private-sector economists, and published by the Blue Chip Publications division of Aspen Publishers. The data are available as far back as 1976. Blue Chip consensus forecasts are collected on the first three working days of the month.[11] We use the consensus forecast, which are average of the forecasts across the panel of interviewed professionals.

We construct our measures of the surprise component of the Fed Greenbook forecasts by taking the Greenbook forecast for a given variable and horizon, and subtracting the Blue Chip equivalent from it.[12]

[10] The data are available here: https://www.philadelphiafed.org/surveys-and-data/real-time-data-research/philadelphia-data-set.

[11] Bauer and Swanson (2021) report that beginning in December 2000, the Blue Chip survey is completed by the second business day of each month.

[12] Note that for a small number of observations, i.e. those on the first three business days of the month, the FOMC meeting may antedate the Blue Chip forecasts, potentially contaminating the measure of the surprises for these dates. Lakdawala and Schaffer (2019) account for this by defining a cut-off at the 10th of each month, and for FOMC meetings coming before the 10th of a given month use the Blue Chip forecast released on the 10th of the previous month. We prefer not to adopt this strategy, since while it would ensure the Blue Chip forecasts always antedate the meetings, it risks conferring an unfairly large information advantage to the Fed for those meetings that occur prior to the 10th. We prefer to subtract Blue Chip from Greenbook forecasts without applying correction approaches, which themselves may impart bias.

Table 1: Purging Regressions, Greenbook, 1994-2008 Sample

	OUR AS	OUR CS	FF3/AS	FF4/AS	FF5/AS	FF6/AS	ED4/AS	ED8/AS	ED12/AS	2YT/AS	5YT/AS	10YT/AS	S21 FG	S21 FG (S)
UNEMPF0	-0.008	0.002	-0.040	-0.081	-0.108	-0.082	-0.024	0.035	0.036	0.060	0.053	0.055	-0.084	-0.068
gRGDPB1	-0.124	-0.007	-0.019	-0.011	-0.025	-0.064	-0.082	-0.092	-0.071	-0.115	-0.093	-0.056	-0.003	-0.051
gRGDPF0	0.178	0.046	-0.069	0.029	0.071	0.068	0.115	0.197	0.252**	0.197	0.211*	0.207*	0.117	0.048
gRGDPF1	-0.404**	0.122	0.307*	0.292*	0.209	0.327**	0.202	0.037	-0.025	0.046	0.002	-0.012	0.378**	0.304*
gRGDPF2	0.079	0.082	0.065	0.049	0.119	0.089	0.164	0.184	0.189	0.054	0.124	0.184	0.192	0.206
gPGDPB1	-0.330*	-0.041	-0.196	-0.261	-0.230	-0.256	-0.150	-0.016	0.053	-0.048	-0.044	-0.043	-0.058	-0.022
gPGDPF0	-0.075	0.286	0.181	0.168	0.180	0.185	0.271	0.211	0.196	0.167	0.193	0.161	0.202	0.239
gPGDPF1	-0.109	0.141	0.105	0.067	0.059	-0.007	-0.237	-0.306	-0.226	-0.238	-0.203	-0.216	-0.450*	-0.514*
gPGDPF2	0.016	0.689*	0.417	0.379	0.301	0.230	-0.116	-0.354	-0.393	-0.428	-0.414	-0.302	0.186	0.105
L.gRGDPB1	-0.028	-0.036	-0.087	-0.072	-0.052	-0.056	-0.045	-0.040	-0.045	-0.039	-0.072	-0.110*	0.051	0.084
L.gRGDPF0	-0.130	0.146	0.216*	0.144	0.183	0.188	0.191	0.121	0.015	0.144	0.035	-0.006	0.081	0.106
L.gRGDPF1	0.480***	-0.021	0.066	0.034	-0.014	-0.021	-0.034	-0.073	-0.027	-0.041	0.058	0.063	-0.103	-0.056
L.gRGDPF2	0.036	-0.345**	-0.421**	-0.379**	-0.384**	-0.447***	-0.498***	-0.379**	-0.358**	-0.317*	-0.359**	-0.374**	-0.589***	-0.565***
L.gPGDPB1	0.314*	0.311*	0.381**	0.416***	0.461***	0.473***	0.433***	0.317*	0.265	0.378**	0.350**	0.320*	0.331**	0.291
L.gPGDPF0	0.197	-0.507***	-0.395**	-0.289*	-0.306*	-0.222	-0.252	-0.185	-0.192	-0.137	-0.104	-0.120	-0.252	-0.279
L.gPGDPF1	0.463*	0.050	0.288	0.264	0.247	0.276	0.395	0.322	0.307	0.244	0.290	0.425	0.569**	0.712**
L.gPGDPF2	-0.624	-0.902**	-0.707*	-0.636	-0.565	-0.563	-0.302	-0.006	-0.007	0.034	-0.062	-0.231	-0.445	-0.399
R^2	0.23	0.20	0.27	0.26	0.28	0.30	0.27	0.19	0.18	0.20	0.19	0.18	0.30	0.25
$F(17)$	1.86	1.44	2.15	2.13	2.28	2.53	2.31	1.43	1.30	1.49	1.43	1.41	2.50	1.97
p-value	0.03	0.13	0.01	0.01	0.01	0.00	0.01	0.14	0.21	0.11	0.14	0.15	0.00	0.02
N	115	115	115	115	115	115	115	115	115	115	115	115	115	115

Notes: Table shows coefficients from regressions of identified monetary policy surprises (respectively action and communication) on FOMC Greenbook data. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Purging Regressions, Greenbook Subtract Blue Chip, 1994-2008 Sample

	OUR AS	OUR CS	FF3/AS	FF4/AS	FF5/AS	FF6/AS	ED4/AS	ED8/AS	ED12/AS	2YT/AS	5YT/AS	10YT/AS	S21 FG	S21 FG (S)
UNEMPF0	1.722	-0.981	-1.940*	-1.382	-1.007	-0.539	-0.319	0.245	1.101	0.591	1.097	1.384	-0.080	-0.140
gRGDPB1	-0.007	0.007	-0.097	-0.036	0.029	-0.020	-0.115	-0.165	-0.008	-0.063	0.022	0.118	-0.107	-0.240
gRGDPF0	0.486***	0.110	-0.053	0.086	0.150	0.180	0.296*	0.364**	0.443**	0.400**	0.408**	0.343*	0.232	0.119
gRGDPF1	-0.369	0.206	0.471**	0.403*	0.258	0.416*	0.282	0.091	-0.004	0.033	0.011	0.022	0.500**	0.477*
gRGDPF2	0.166	0.044	0.019	0.027	0.133	0.087	0.300	0.322*	0.305	0.108	0.211	0.353*	0.243	0.190
gPGDPB1	-0.488	0.143	-0.023	-0.154	-0.162	-0.250	-0.789**	-0.619*	-0.473	-0.548	-0.493	-0.395	-0.588	-0.558
gPGDPF0	0.068	0.210	0.086	0.132	0.201	0.267	0.394**	0.364*	0.380*	0.316	0.422**	0.452**	0.272	0.222
gPGDPF1	-0.279	-0.179	-0.216	-0.207	-0.194	-0.281	-0.726**	-0.711**	-0.518*	-0.495	-0.420	-0.402	-0.824**	-0.928***
gPGDPF2	0.047	0.726*	0.389	0.539	0.602	0.624	0.330	0.082	0.021	0.015	0.084	0.297	0.371	0.146
L.gRGDPB1	-0.152	-0.173	-0.277	-0.235	-0.225	-0.279	-0.361*	-0.391*	-0.393*	-0.345*	-0.438**	-0.417**	-0.218	-0.274
L.gRGDPF0	-0.299*	0.258	0.239	0.222	0.260	0.279	0.308*	0.306*	0.200	0.254	0.147	0.164	0.278	0.228
L.gRGDPF1	0.339	0.073	0.152	0.155	0.126	0.096	-0.026	-0.156	-0.115	-0.029	-0.006	-0.108	-0.017	0.010
L.gRGDPF2	0.076	-0.264	-0.370*	-0.281	-0.247	-0.336*	-0.422**	-0.303	-0.288	-0.228	-0.328	-0.382*	-0.499**	-0.462*
L.gPGDPB1	0.085	0.169	0.110	-0.055	-0.085	-0.029	-0.027	0.161	0.273	0.322	0.214	0.180	0.110	-0.129
L.gPGDPF0	0.032	-0.343*	-0.285	-0.220	-0.234	-0.189	-0.153	-0.123	-0.171	-0.078	-0.121	-0.221	-0.100	-0.111
L.gPGDPF1	-0.018	-0.021	0.099	-0.046	-0.115	-0.150	-0.088	-0.068	-0.059	-0.158	-0.148	0.005	0.342	0.528
L.gPGDPF2	-0.096	-0.304	-0.150	-0.105	-0.111	-0.170	0.138	0.283	0.236	0.311	0.134	-0.121	-0.273	-0.215
R^2	0.18	0.19	0.28	0.26	0.24	0.26	0.29	0.23	0.20	0.20	0.18	0.16	0.25	0.20
$F(17)$	1.24	1.42	2.20	2.07	1.83	2.04	2.33	1.71	1.45	1.46	1.30	1.14	1.95	1.41
p-value	0.25	0.14	0.01	0.01	0.03	0.02	0.00	0.05	0.13	0.13	0.21	0.33	0.02	0.15
N	115	115	115	115	115	115	115	115	115	115	115	115	115	115

Notes: Table shows coefficients from regressions of identified monetary policy surprises (respectively action and communication) on variables constructed as the difference between FOMC Greenbook data and Blue Chip forecasts. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Purging Regressions, Greenbook, 1994-2015 Sample

	ED4	ED8	ED12
UNEMPF0	-0.042	0.005	0.008
gRGDPB1	-0.078	-0.018	0.061
gRGDPF0	0.211**	0.013	0.118
gRGDPF1	0.211*	-0.095	0.228*
gRGDPF2	0.183	0.222*	0.009
gPGDPB1	0.055	0.411***	0.050
gPGDPF0	0.258**	-0.061	-0.133
gPGDPF1	-0.056	-0.085	0.054
gPGDPF2	-0.089	-0.091	-0.135
L.gRGDPB1	-0.018	0.050	-0.008
L.gRGDPF0	0.131	-0.024	-0.278***
L.gRGDPF1	-0.115	-0.285**	0.072
L.gRGDPF2	-0.437***	0.080	-0.153
L.gPGDPB1	0.137	-0.167	-0.070
L.gPGDPF0	-0.180	-0.254*	-0.049
L.gPGDPF1	-0.041	0.028	0.209
L.gPGDPF2	-0.100	0.314	-0.011
R^2	0.26	0.16	0.14
$F(17)$	3.70	1.87	1.53
p-value	0.00	0.02	0.09
N	175	175	175

Notes: Table shows coefficients from regressions of identified monetary policy surprises on FOMC Greenbook data. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

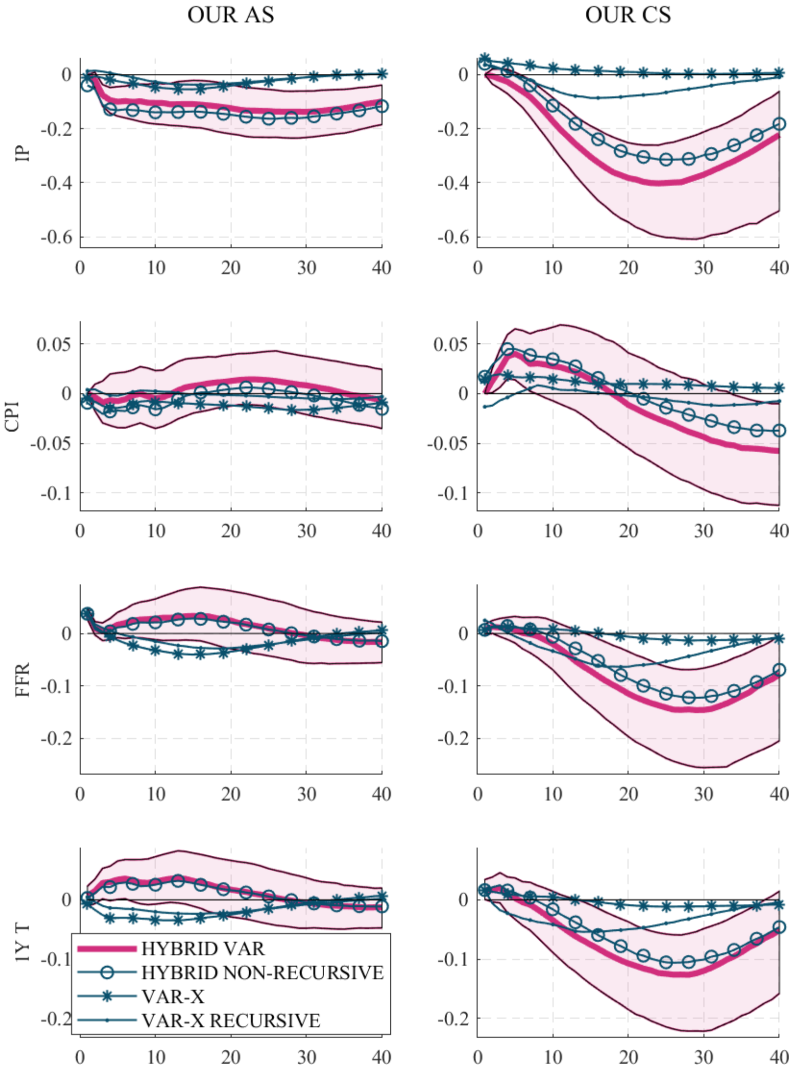
Table 4: Purging Regressions, Greenbook Subtract Blue Chip, 1994-2015 Sample

	ED4	ED8	ED12
UNEMPF0	0.219	0.522	1.559**
gRGDPB1	-0.049	-0.160	0.242
gRGDPF0	0.308**	-0.093	0.031
gRGDPF1	0.349**	-0.240	0.247
gRGDPF2	0.189	0.040	0.047
gPGDPB1	-0.240	0.386	0.275
gPGDPF0	0.090	-0.119	-0.282*
gPGDPF1	-0.505**	0.021	-0.076
gPGDPF2	0.034	-0.111	-0.382
L.gRGDPB1	-0.211	0.077	0.161
L.gRGDPF0	0.309**	0.174	-0.471***
L.gRGDPF1	-0.103	-0.320*	0.239
L.gRGDPF2	-0.205	0.288	-0.183
L.gPGDPB1	-0.302	0.450**	-0.184
L.gPGDPF0	-0.028	-0.130	-0.244
L.gPGDPF1	-0.079	0.123	0.268
L.gPGDPF2	0.517*	0.102	0.208
R^2	0.24	0.14	0.20
$F(17)$	2.84	1.36	2.27
p-value	0.00	0.16	0.00
N	175	175	175

Notes: Table shows coefficients from regressions of identified monetary policy surprises on variables constructed as the difference between FOMC Greenbook data and Blue Chip forecasts. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

2.2 Alternative VAR Specifications

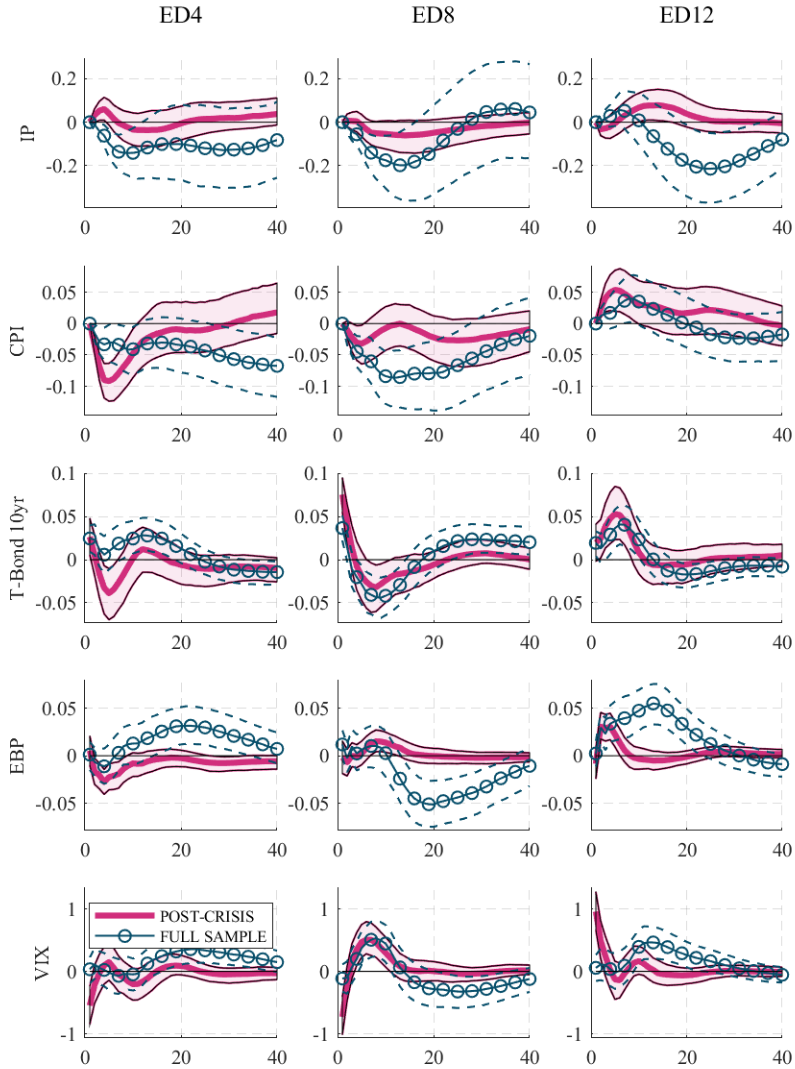
Figure 1: Comparison With VAR-X: Unpurged



Notes: Sample period: 1994m3-2008m6. The first column shows the response to an action shock, the second column the response to a communication shock in our baseline Hybrid VAR. We display only the responses of (log) IP, (log) CPI, federal funds rate and the one-year Treasury yield from the 9-variable system. The shocks are one-standard deviation. Estimates are derived from 1,000 draws from the posterior. The Hybrid Non-Recursive specification is a Hybrid BVAR identical to the baseline with the instrument ordered first in the vector. The VAR-X specification uses the same variables as in the baseline Hybrid BVAR, however the shock is entered into an exogenous block. The VAR-X Recursive specification is identical to the VAR-X, however the instrument is first orthogonalised with respect to the first lag of all the endogenous variables, and contemporaneous values of slow-moving endogenous variables, and 12 lags of the shock itself.

2.3 Further Eurodollar Results

Figure 2: Eurodollar Shocks – ELB Period vs. Full Sample – Unpurged



Notes: Results from the Eurodollar BVAR model, for six of the macroeconomic and financial variables in the 9-variable system (sample period: 1994m3-2015m12). The three columns display respective impulse responses for ED4, ED8 and ED12 shocks. We display only surprises that have are unpurged, and are not orthogonalised with respect to the internal information of the Federal Reserve. We compare responses to the full-sample and post-crisis periods. We display the 68% credible set. Estimates are derived from 1,000 draws from the posterior.

3 Our Shocks and Their Correlation to Other Shock Measures

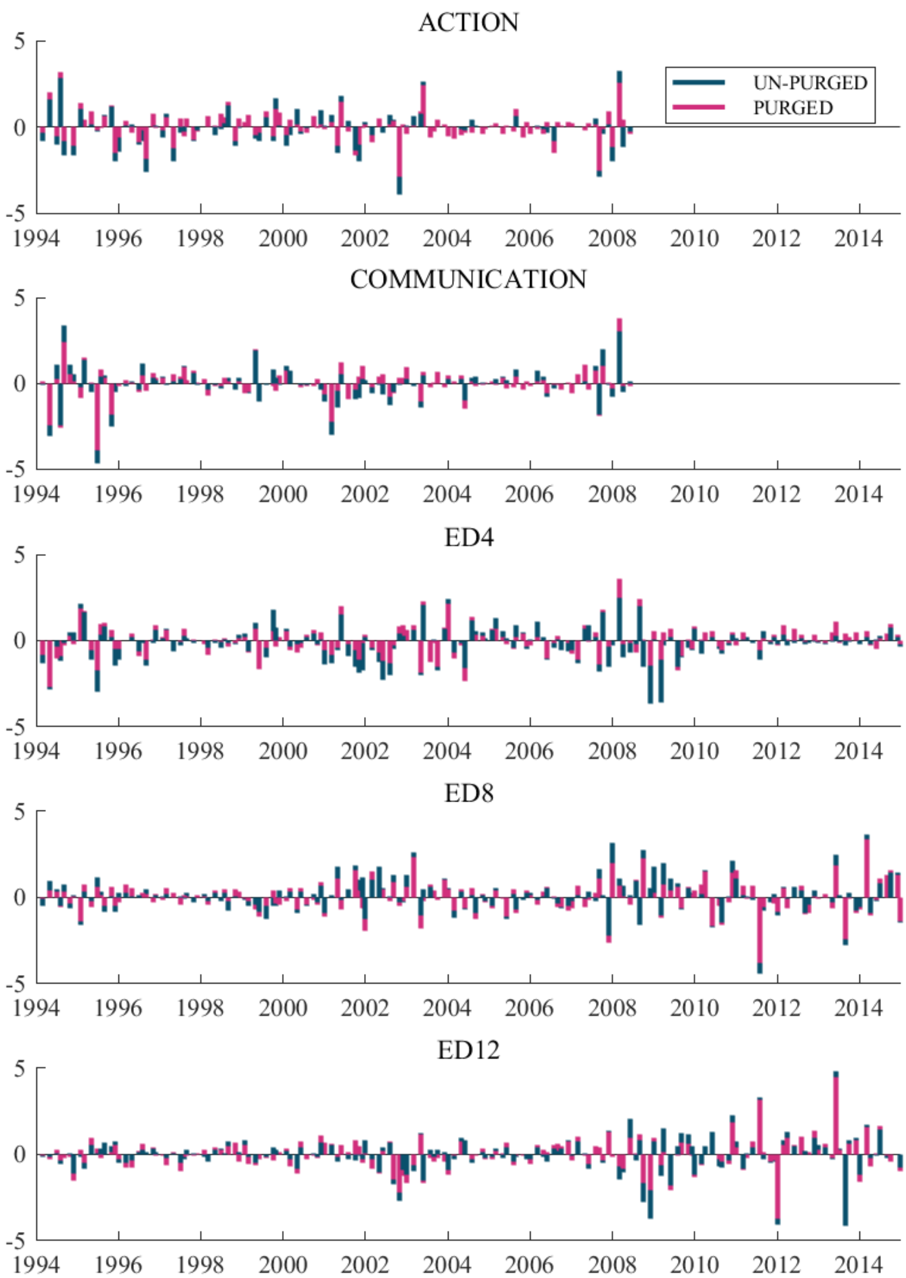
3.1 Baseline Shocks and Some Discussion

Figure 3 plots the shock series derived from the federal funds futures (FFF) contracts for the sample period 1994-2008, as well as the shock series derived from the Eurodollar (ED) contracts for the sample period 1994-2015.

Consider the action and communication shock from the FFF-derived shocks. We see that the size of both action and communication surprises during FOMC meetings is relatively small. This implies that markets generally anticipate decisions with a high precision. The shock series show increased volatility after the bursting of the dot-com bubble and 9/11, and during the immediate run-up to the financial crisis.

When considering the ED4, ED8, and ED12 surprises, we observe that the volatility of the ED4 surprise remains relatively constant, barring some large realisations during the financial crisis of 2008-09. As we consider the ELB period, the volatility of this series markedly drops. During this same period, we observe that the volatility of the ED8 and ED12 surprise increases, as the Fed increasingly relied on forward guidance about more distant outcomes, and market expectations regarding imminent rate hikes were contained by communication strategies.

Figure 3: Shock Series



Notes: In this figure we display orthogonalised action and communication surprises, and orthogonalised surprises based on Eurodollar data. We are additionally report shock series that are extracted as the residual from purging regressions in each case. Each of the unpurged series has a standard deviation equal to 1. The standard deviation of the purged surprise is not re-normalised.

3.2 Correlation with Other Shocks

Table 5 displays the correlation of our shock with other widely used measures of monetary policy shocks from the literature. From panel (a) we observe that our action surprise is actually more highly correlated with the Barakchian and Crowe (2013) surprise, than the communication surprise. This property is also true for the relation between our surprises and the Miranda-Agrippino and Ricco (2021) surprise. We can conclude that there is a substantial portion of the movement in these two surprises that relates to Fed actions. This motivates our separate handling of the two sources of surprise. We can also observe that our communication surprise is positively correlated with the forward guidance surprise of Swanson (2021), however the two shocks are not reducible to each other since the correlation is only 0.50. From panel (b) we can see that many of these broad conclusions hold also in the purged cases, where the coefficients are comparable.

In panels (c) and (d) of Table 5 we observe that the ED4 surprise is positively related to the Swanson (2021) target and forward guidance surprises. The ED8 surprise is actually negatively related to the target surprise, and positively related to the FG surprise, while the ED12 surprise is positively related to the target surprise. One explanation for the negative relation between the ED8 surprise and the target surprise is that for this form of forward guidance the Fed has a tendency to offset contemporaneous contraction with future expansion. These relationships are consistent with the purged cases.

Table 5: Shock Correlations

(a) 1994-2008 Sample, Unpurged

	BC13	Target S21	FG S21	MAR21
ACTION	0.74***	0.89***	-0.11	0.61***
COMMUNICATION	0.59***	0.19**	0.50***	0.40***

(b) 1994-2008 Sample, Purged

	BC13†	Target S21†	FG S21†	MAR21
ACTION†	0.73***	0.88***	-0.15*	0.54***
COMMUNICATION†	0.58***	0.18**	0.44***	0.34***

(c) 1994-2015 Sample, Unpurged

	Target S21	FG S21
ED4	0.35***	0.71***
ED8	-0.25***	0.13*
ED12	0.19**	0.04

(d) 1994-2015 Sample, Purged

	Target S21†	FG S21†
ED4†	0.34***	0.65***
ED8†	-0.22***	0.21***
ED12†	0.17**	-0.07

Notes: Table shows correlation coefficients between shock series, computed on scheduled meetings. Shock series marked with † have been orthogonalised with respect to Greenbook data by the authors. "BC13": Barakchian and Crowe (2013); "S21": Swanson (2021); "MAR21": Miranda-Agrippino and Ricco (2021). Note that the surprise of Miranda-Agrippino and Ricco (2021) is already orthogonalised with respect to Greenbook data, so we do not orthogonalise this surprise again. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4 Details on the Bayesian VAR Specification

The VAR-X model specified in Equation (3) of the main paper can be written in matrix notation as

$$Y = XB' + E, \tag{1}$$

where $Y \equiv [\mathbf{Y}_{p+1} \ldots \mathbf{Y}_T]'$, $X = [X'_p, \ldots, X'_{T-1}]'$, with $X_{t-1} \equiv (\mathbf{Y}'_{t-1}, \ldots, \mathbf{Y}'_{t-p}, 1)$, $B \equiv [C_1, \ldots, C_p, C_c]$, and $E \equiv [\varepsilon_{p+1}, \ldots, \varepsilon_T]'$. Let $\beta = vec(B')$.

We assume the following joint improper prior for β and Σ_ε:

$$\pi_0(\beta, \Sigma_\varepsilon) \sim |\Sigma_\varepsilon|^{-(\upsilon_0+n+1)/2}.$$

We augment the data matrices (Y and X) with T^* dummy observations that are designed to impose a given prior, to be discussed below. Let the dummy observations be represented by Y^* and X^*, respectively $(T^* \times n)$ and $(T^* \times k)$ matrices, where $k = n * p + 1$. Let $\bar{Y}$ and $\bar{X}$ represent the augmented data, with $\bar{Y} = [Y', Y^{*\prime}]'$ and $\bar{X} = [X', X^{*\prime}]'$.[13] In this case the posterior is analytically available and of the form:

$$(B, \Sigma_e) \mid \bar{Y} \sim MNIW\left(\hat{\bar{B}}, (\bar{X}'\bar{X})^{-1}, \hat{\bar{S}}, \bar{T} - k + \upsilon_0\right), \tag{2}$$

where $\hat{\bar{B}}' = (\bar{X}'\bar{X})^{-1}\bar{X}'\bar{Y}$, $\hat{\bar{S}} = (\bar{Y} - \bar{X}\hat{\bar{B}}')'(\bar{Y} - \bar{X}\hat{\bar{B}}')$, $\bar{T} = T + T^*$, and $MNIW(\cdot)$ refers to the multivariate-normal-inverse-Wishart distribution.

As discussed in the main text, the prior for the coefficient means is set equal to zero for all cases excepting first-order autocorrelations. In this case, the prior mean varies depending on whether the variable is stationary (when the prior mean is also set to zero) or non-stationary (in which case the prior mean is set to equal one). Denote the $(n \times 1)$ vector of prior means for the auto-correlation parameters as β_0.

The variances of the prior for the coefficients $\{B_l\}_{l=1}^{l=p}$ is set according to the Litterman scheme, therefore the coefficient for the effect of the lth lag of variable j on variable i, $(B_l)_{ij}$, has prior variance given by:

$$V\left[(B_l)_{ij}\right] = \begin{cases} \frac{\lambda_1^2}{l^2}, & \text{if } j = i, \\ \frac{\lambda_1^2}{l^2}\frac{\sigma_i^2}{\sigma_j^2}, & \text{otherwise,} \end{cases}$$

for all lags l, and for all pairings of variables i and j. Here the parameters $\{\sigma_i\}_{i=1}^{i=n_y}$ are set as the estimated standard deviations of the residuals from univariate p-order auto-regressions of the respective variables in the VAR system, as is standard in the literature. We set λ to 0.2. The prior for the intercept has a zero mean, and a large variance, determined by the parameter λ_4.

The dummy observation matrices, which implement the prior, are specified according to the set-up of Bańbura et al. (2010). Therefore Y^* and X^* are defined as follows:

$$Y^* = \begin{pmatrix} diag(\beta_{0,1}\sigma_1, \ldots, \beta_{0,n}\sigma_n) * \lambda_1^{-1} \\ 0_{n(p-1)\times n} \\ diag(\sigma_1, \ldots, \sigma_n) \\ 0_{1\times n} \end{pmatrix},$$

$$X^* = \begin{pmatrix} J_p \otimes diag(\sigma_1, \ldots, \sigma_n) * \lambda_1^{-1} & 0_{np\times 1} \\ 0_{n\times np} & 0_{n\times 1} \\ 0_{1\times np} & \lambda_4^{-1} \end{pmatrix}.$$

Here J_p is defined as $J_p = diag(1, 2, \ldots, p)$. The number of dummy observations, T^*, is therefore equal to $np + n + 1$. To construct estimates we draw directly from the posterior distribution of Equation 2, using Monte Carlo sampling.[14]

[13] Adding these dummy observations to the system in conjunction with the improper prior $\pi_0(\beta, \Sigma_e)$ is equivalent to imposing a multivariate-normal inverse-Wishart prior $MNIW(\hat{B}^*, (X^{*\prime}X^*)^{-1}, S^*, T^* - k + \upsilon_0)$, with $\hat{B}^* = (X^{*\prime}X^*)^{-1}X^{*\prime}Y^*$ and $S^* = (Y^* - X^*B^*)'(Y^* - X^*B^*)$, and where $k = n * p + 1$.

[14] This is described in Algorithm 2.1 of Del Negro and Schorfheide (2011).

References

Bańbura, Marta, Domenico Giannone, and Lucrezia Reichlin (2010) “Large Bayesian Vector Auto Regressions,” *Journal of Applied Econometrics*, 25, 71–92.

Barakchian, S. Mahdi and Christopher Crowe (2013) “Monetary Policy Matters: Evidence from New Shocks Data,” *Journal of Monetary Economics*, 60 (8), 950–966.

Bauer, Michael D. and Eric T. Swanson (2021) “An Alternative Explanation for the "Fed Information Effect",” Working Paper Series 2020-06, Federal Reserve Bank of San Francisco, September.

Del Negro, Marco and Frank Schorfheide (2011) “Bayesian Macroeconometrics,” in John Geweke, Gary Koop and Herman Van Dijk eds. *The Oxford Handbook of Bayesian Econometrics*, Chap. 7, 293–389: Oxford University Press.

Gürkaynak, Refet S. (2005) “Using federal funds futures contracts for monetary policy analysis,” (2005-29).

Gürkaynak, Refet S., Brian Sack, and Eric T. Swanson (2004) “Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements,” Finance and Economics Discussion Series 2004-66, Board of Governors of the Federal Reserve System (U.S.), November.

——— (2005) “Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements,” *International Journal of Central Banking*, 1 (1), 55–93.

Kuttner, Kenneth N. (2001) “Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market,” *Journal of Monetary Economics*, 47 (3), 523–544.

Lakdawala, Aeimit and Matthew Schaffer (2019) “Federal reserve private information and the stock market,” *Journal of Banking & Finance*, 106, 34 – 49.

Miranda-Agrippino, Silvia and Giovanni Ricco (2021) “The Transmission of Monetary Policy Shocks,” *American Economic Journal: Macroeconomics*, 13 (3), 74–107.

Swanson, Eric T. (2021) “Measuring the effects of federal reserve forward guidance and asset purchases on financial markets,” *Journal of Monetary Economics*, 118 (C), 32–53.