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Abstract

Using textual analysis of the largest dealers' newsletters to their clients, we construct a measure of uncertainty about the Federal Reserve's balance sheet policy (BSP). This measure of uncertainty tends to spike during the introduction of novel aspects of BSP or at its turning points, with the largest spike occurring during the "Taper Tantrum" period. We find that positive shocks to BSP uncertainty increase longer-term Treasury yields, private borrowing costs, private MBS duration, and reduce mortgage refinance volumes. As a result, an increase in BSP uncertainty has contractionary effects similar to those of a monetary-policy tightening shock. Further, post-2008, these effects seem quite different from those of broader monetary policy uncertainty and fiscal policy uncertainty. Overall, our findings suggest that explicit forward guidance about the Fed's balance-sheet path might be warranted.

Keywords: Federal Reserve's Balance Sheet, Uncertainty, Risk Premia, SVAR
JEL Classifications:

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1 Introduction

Since the Federal Reserve (Fed) has conducted balance sheet policy (BSP), the episode of the "taper tantrum" in May-June 2013 remains the largest market reaction ever observed to changes in the stance of BSP. The taper tantrum occurred as the Fed was transitioning from quantitative easing (QE) to quantitative tightening (QT) for the first time, and D'Amico and Seida (2024) find that higher market uncertainty amplifies the yield effects of BSP announcements, particularly at turning points of BSP. These two observations motivated us to investigate the effects of investor uncertainty about the Fed's BSP in financial markets and the broader economy.

Specifically, the Survey of Primary Dealers (SPD) indicates that in the period bracketing the taper tantrum,[1] the Fed asset purchases expected over the next year declined by $445 billions. This reduction, based on the average yield sensitivity estimated in the literature,[2] should have pushed the nominal 10-year Treasury yield up by 18 basis points, with a maximum of 45 basis points. In contrast, during the taper tantrum, longer-term yields increased by about 120 basis points, roughly 3 times the effect predicted by the largest QE yield sensitivity. Is there an explanation? Did investor uncertainty about BSP play a role in this out-sized reaction?

Publications from major primary dealers seem to suggest it may. For instance, in September 2013, a newsletter from one of the largest primary dealers to its clients reported the following: "With no clear guidance from the Fed on the criteria it will use to decide when to taper, uncertainty about this decision is very high." We use textual analysis of this type of newsletters to measure investor BSP uncertainty. The novel use of this source of information, differently from newspapers articles, allows us to capture the unfiltered opinion of large dealers who tend to be careful Fed watchers. Further, large dealers convey their own uncertainty to their clients and therefore influence the view of the broader market.

To investigate the role of BSP uncertainty, we had to start from its measurement because, differently from other types of policy uncertainty,[3] there is no research focused on BSP uncertainty. Then, we analyze how this uncertainty propagates to key financial and economic variables; and finally, we try to understand how its economic effects differ from those of other

[1] The Federal Reserve Bank of New York conducts the SPD 8 times per year, about a week before each FOMC meeting. The surveys of April and September 2013 provide information on dealers' expectations just before and after the taper tantrum period.

[2] On average, $100 billion worth of Treasury purchases are estimated to reduce Treasury yields by 4 basis points, with a maximum of about 10 basis points, under the assumption of symmetric QE and QT effects.

[3] See, for instance, Baker, Bloom, and Davis (2016) for economic policy uncertainty, including monetary and fiscal policy uncertainty; Husted, Rogers, and Sun (2019) also for monetary policy uncertainty; Cieslak, Hansen, McMahon, and Xiao (2022) for policymakers' uncertainty.

forms of policy uncertainty.

We believe it is important to focus on BSP uncertainty for various reasons. First, BSP is a relatively novel monetary-policy tool and policymakers' reaction function for this tool is little understood; nevertheless, BSP has been used extensively by all the major central banks over last 15 years, especially during periods of crisis. Second, policymakers have often cited uncertainty about this tool as a constraint on its use (e.g., Bernanke, 2020), hence distinguishing between uncertainty about the balance-sheet and short-rate tools can provide important insights for their relative use.[4] Third, evaluating the financial and economic impact of BSP uncertainty should help us understand whether explicit forward guidance (FG) about the balance-sheet path should be used to reduce such uncertainty. Finally, it is also relevant to understand whether different forms of BSP (e.g., Carlson et al., 2020) create different degree of uncertainty and therefore require different degree of FG.

To measure investor BSP uncertainty, we use textual analysis of the major dealers' newsletters to their clients. In particular, our BSP uncertainty (BSPU) index is constructed from the fraction of uncertainty-related words in sentences mentioning both Fed-related words and BSP-related words. This ensures that the likelihood of capturing only the degree of uncertainty perceived by investors about the Fed's BSP is very high. In other words, by carefully controlling for the context within which uncertainty-related words are used, we try to make sure that the uncertainty we measure is neither about the Fed's policy rate, nor about other banks' or central banks' balance sheets. To externally validate the BSPU index, we analyze its most notable spikes and find that they mostly coincide with the introduction of novel aspects of BSP. Indeed, the taper tantrum is associated to the largest spike.

Once we construct our BSPU index, we provide new evidence on how shocks to this index propagate to key financial and economic variables using a structural VAR (SVAR) approach. Importantly, in the VAR, we also include a measure of expectations about the size of the Fed's balance sheet (Kim, Laubach, and Wei, 2023), as one cannot omit the "first moment" when analyzing the effects of the second moment—BSP uncertainty. This allows us to uncover the *perceived* risk management response to a rise in BSPU: investors, on average, expect the Fed to increase the size of its balance sheet in the near future to offset the tightening in financial conditions induced by the increase in BSPU. This endogenous reaction of the first moment to the second moment of BSP dampens the contractionary effects of BSPU. Hence, to isolate the economic response to BSPU shocks, we need to strip out the stimulative impact induced by the endogenous risk management response. To do so, we use the SVAR estimates to build counterfactual impulse responses to BSPU shocks in

[4]For instance, in Williams (2013), under uncertainty, the optimal strategy is to use the policy tool with the least uncertainty to its fullest extent before turning to other tools characterized by greater uncertainty.

the absence of the perceived risk management reaction.

We find that positive BSPU shocks increase significantly longer-term Treasury yields, the excess bond premium (Gilchrist and Zakrajsek, 2012), mortgage rates, private MBS duration, and reduce mortgage refinance volumes. As a result, these shocks have contractionary effects on IP and CPI, although the latter is not statistically significant. Overall, a positive BSPU shock has economic effects very similar to those of a monetary-policy tightening shock. We then use the SVAR estimates to quantify the role of BSPU in the taper tantrum, which is characterized by a sequence of BSPU shocks. In the absence of the perceived risk management response that followed this sequence of shocks, the 10-year Treasury yield and excess bond premium would have been about 90 and 70 basis points higher, respectively, because of BSPU alone. This would have caused a contraction of almost 3 percentage points in the level of IP after about one year. These large effects from a sequence of uncertainty shocks of the same sign are in line with the amplifying mechanism shown in Diercks et al. (2023).

In alternative VAR specifications, we also control for fiscal policy uncertainty (FPU) using the index of Baker, Bloom, and Davis (2016), and for broader monetary policy uncertainty (MPU) using the index of Husted, Rogers, and Sun (2019). Omitting these variables could cause an overestimation of the impact of our BSPU index. However, their inclusion in the VAR does not affect our baseline results. Finally, we find that, post 2008, the effects of BSPU shocks are quite different from the effects of shocks to FPU and MPU. Shocks to these policy uncertainties have impacts similar to those that would be observed in response to uncertainty about a demand shock. Hence, the longer-term Treasury yield premium declines rather than increasing.

Overall, our findings indicate that, post 2008, BSP uncertainty has played an important role, implying that explicit FG about the Fed's balance sheet path might be warranted. Importantly, the estimation of a significant perceived risk management response that dampens the contractionary effects of BSPU, suggests that the Fed might have been successful in using a risk management approach to BSP.

The rest of our paper is organized as follows. In Section 2, we detail the construction of the BSPU index. In Section 3, we present our SVAR specification and main estimation results. In Section 4, we quantify the role of BSPU in the taper tantrum. In Section 5, we investigate additional transmission channels of BSPU. In Section 6 and 7, we run some robustness exercises and compare the effects of BSPU shocks to those of other types of policy uncertainty. We provide concluding remarks in Section 8.

2 The BSPU Index

We are interested in investor uncertainty about BSP. To capture it we use textual analysis of the investment bank newsletters (IBNLs) of the major primary dealers to their clients.[5] We favor the use of textual analysis for various reasons. First, it enables us to isolate uncertainty about BSP. Second, it avoids contamination from risk premia as it is not a market-based measure. Third, relative to surveys, it can be measured at a higher frequency and there are no incentives to "game" the survey as the dealers are providing information to their clients. There are, however, a couple of shortcomings from measuring uncertainty using textual analysis: the ambiguity about the unit of measurement and time-horizon of such uncertainty. It is possible that our index will be mostly capturing short-term uncertainty as the IBNLs mostly focus on timely topics for the upcoming FOMC meetings.

Specifically, we use the IBNLs of five major dealers from January 2009 until August 2022.[6] To construct our index we proceed as follows. For each dealer, we look for text related to the Fed's BSP and count "uncertainty" related words in this context. We then control for the changing volume of publications and Fed related text over time, as well as the possibility that some dealers cover more BSP than others. Lastly, we average across dealers.

To build the BSP-relevant text, we flag any sentence that **both** contains a Balance-Sheet-related word or "bigram" (set of 2 words) **and** either contains a Fed-related word/bigram itself, or is preceded by or followed by a sentence which contains a Fed-related word/bigram. The second qualification ensures that the discussion of a balance-sheet-related topic is in the context of the Federal Reserve and not another financial entity or central bank.[7] Then, we take the sentence itself, the one before, and the one after for context. Finally, within this context, we search for uncertain words. The number of uncertainty-related words in the BSP-relevant text constitutes the numerator of our measure, that is, the uncertainty word count (UWC^{BSP}).

The list of words used in the textual analysis is the following:

- **BSP-related words**: soma, qe, qt, tapering, taper, lsap, unconventional, mlf, smccf, pmccf, mep, cap, caps, reinvestment, reinvestments, runoff
- **BSP-related bigrams**: balance sheet, quantitative easing, quantitative tightening,

[5] The information extracted from the IBNLs at the dealer level and the dealers' identity have to remain confidential.

[6] We use these five dealers because being among the largest, they have research teams that are very active in producing high quality newsletters, and they kindly gave us permission to use the IBNLs for research purposes, making them available to us in a consistent manner back to 2009, when BSP became a relevant tool.

[7] Additionally, we remove all sentences that contain words related to other central banks to ensure that we are strictly focusing on the Fed's balance sheet policy.

asset purchase(s)(ing), treasury purchase(s)(ing), mbs purchase(s)(ing), corporate purchase(s)(ing), bond purchase(s)(ing), cmbs purchase(s)(ing), security purchase(s)(ing), asset buying, treasury buying, mbs buying, corporate buying, bond buying, cmbs buying, security buying, credit facility, credit easing, system open, operation twist, maturity extension

- **Fed-related words**: fomc, fed, hawkish, dovish, minutes, powell, yellen, bernanke, chair, meeting, monetary, committee, soma, lsap, mlf, smccf, pmccf
- **Fed-related bigrams**: federal reserve, forward guidance, dot plot
- **Uncertain words**: uncertain, uncertainty, uncertainties

To control for changes in the volume of publications and Fed-related text over time, we build a broader set of Fed-relevant text. That is, we flag any sentence that contains a Fed-related word or bigram; we take the sentence itself, the one before, and the one after; and we use this set of words to control for trends in the volume of IBNLs covering the Fed. That is, we divide the raw uncertainty word count by the total number of words in the sentences mentioning "Federal Reserve." (See Appendix A for detailed summary statistics related to the textual analysis.) This scaling choice also helps addressing issues related to time-varying transparency and coverage of the Fed due to changes in its communication strategy. Hence, for each bank (b) in a given month (t) the uncertainty frequency is given by:

$$UF(b,t) = \frac{UWC^{BSP}(b,t)}{TWC(b,t)},$$

where $TWC(b,t)$ is the total Fed related word count. Subsequently, we normalize the resulting series to have a unit standard deviation over the sample period, which helps to control for the possibility that some dealers cover more BSP than others:

$$UI(b,t) = \frac{UF(b,t)}{STD[UF(b,t)]}$$

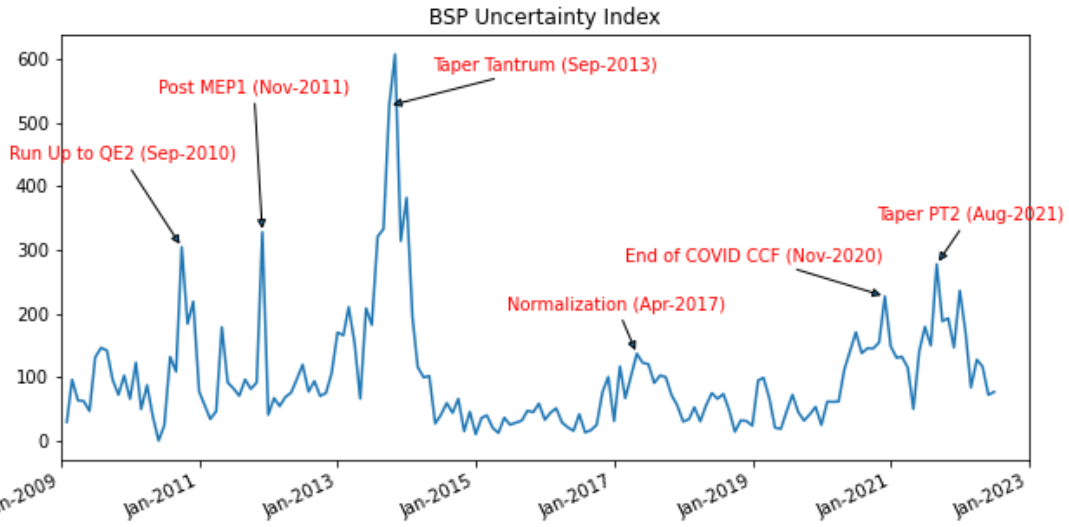
Finally, to obtain the aggregate BSPU index, we take the mean of the $UI(b,t)$ across the banks, $UI(t)$, and scale it to have a mean of 100 over the sample:

$$BSPU(t) = \frac{UI(t)}{AVG[UI(t)]} \times 100$$

Our monthly baseline BSPU index is displayed in Figure 1. The sample runs from January 2009 to August 2022. The index spikes notably: in the month leading to the introduction of

QE2; soon after the announcement of the Maturity Extension Program (MEP1); during the Taper Tantrum; during the first normalization of the Fed's balance sheet; toward the end of 2020 as it became clear that some of the BSP used at the height of the Covid crisis, such as the corporate credit facilities and the municipal liquidity facility would be terminated; and leading to the faster tapering engineered in August 2021. Critically, most of these spikes are not related to changes in the policy rate, suggesting our measure successfully distinguishes between the two tools. (For some key sentences in the IBNLs related to these spikes see Appendix B).

Figure 1. Monthly BSPU Index

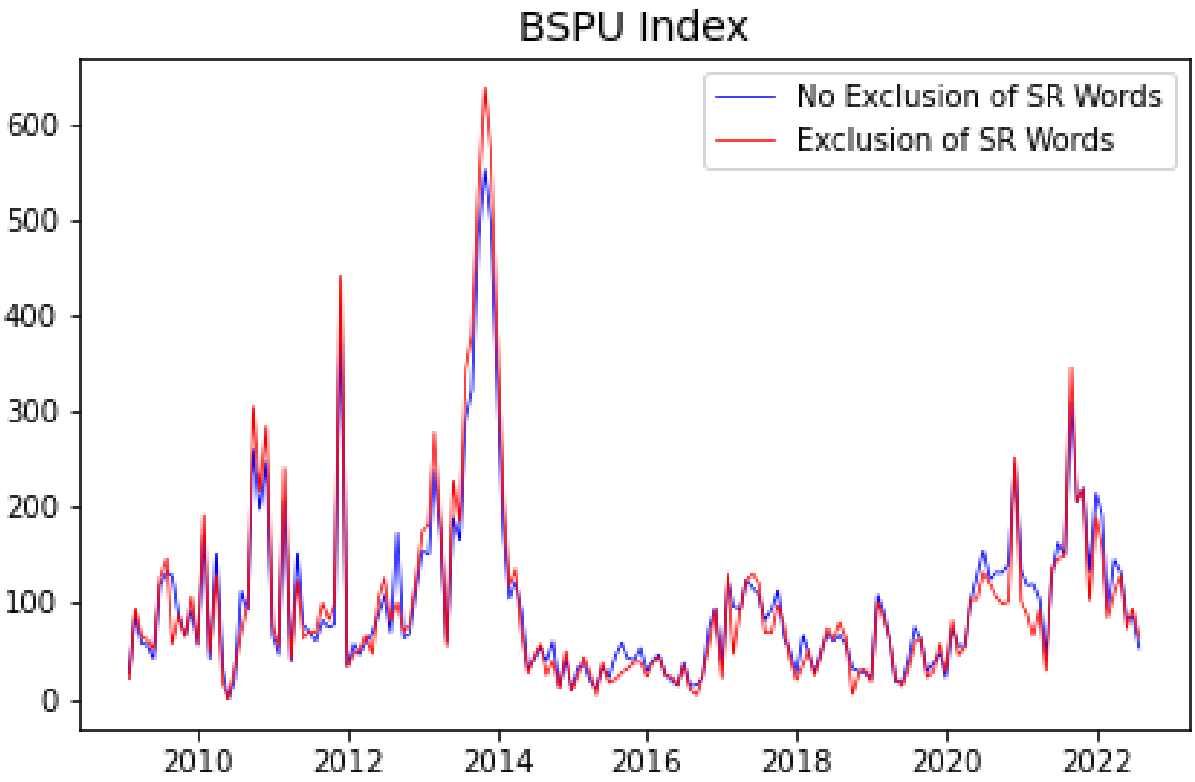


The line depicts the time series of the BSPU measure. The largest spikes have been connected to key changes in the stance on BSP.

However, to ensure that we don't conflate balance sheet policy with short rate policy, we take one more step to remove balance-sheet-related sentences that contain words directly associated with the policy rate, such as: *rate hike, federal funds, funds rate, rate hike(s), rate cut(s), policy rate, short rate, liftoff, ff.*[8] As can be noted from Figure 2, once we remove these words, the index remains roughly similar. In the rest of the paper, we will rely on the BSPU index that excludes words related to the Fed's short rate policy.

[8]We are grateful to our discussant Bo Sun for this suggestion.

Figure 2. Monthly BSPU Index after removing words related to the short-term rate



The blue line depicts the time series of the BSPU index before taking the further step of removing short-rate-related words, and the red line shows the same measure once we remove words related to the policy rate.

In Appendix C, we compare the BSPU index to different proxies of monetary and fiscal policy uncertainty. First, we construct a broader monetary policy uncertainty index, labeled "All-Fed" MPU index, and compare it to the Husted, Rogers and Sun (2020, henceforth HRS) MPU Index, which is constructed from newspaper articles. We find that those two indices behave similarly to each other despite being constructed from different sources; but, both are distinct from the BSPU index, especially in the 2015-2020 period. Second, we analyze how our BSPU index relates to the fiscal policy uncertainty (FPU) index of Baker, Bloom and Davis (2016, henceforth BBD), who also use newspapers articles. We find that, even if the two indices are positively related, they are quite different because of our singular focus on the Fed's balance sheet. In the rest of the paper, we use BBD-FPU as a way to control in part for broader economic uncertainty. We also employ their economic policy uncertainty (EPU) index and obtain very similar results.

3 SVAR specification and baseline results

To examine the effects of BSPU on key financial and economic variables, we use a SVAR and analyze its impulse response functions (IRFs). However, to isolate the impact of BSPU—the "second" moment of BSP—it is necessary to account for its interaction with the first moment of BSP, measured by the expected size of the Fed's System Open Market Account (SOMA) portfolio. If the first two moments of BSP interact positively with each other and affect key interest rates in the opposite direction, then their respective impacts on the economy would tend to offset each other. If we did not control for this interaction, we would not correctly isolate the macroeconomic impact of BSPU shocks, because what we observe in the data is the impact of those shocks *net of* the endogenous economic response induced by the contemporaneous reaction of the first moment to BSPU.

For instance, if an increase in BSPU led to higher interest rates and overall tighter financial conditions relative to the state of the economy, investors might expect the Fed to ease financial conditions by increasing the expected size of SOMA. That is, if the tighter financial conditions were an unintended consequence of Fed's actions and/or communications, investors might expect a risk management approach to BSP.[9] This could occur by delaying the end of QE or by anticipating the end of the balance sheet runoff, possibilities that seemed to have materialized in September 2013 and March 2019, respectively.[10] Indeed, textual analysis of the FOMC transcripts, shown in Figure 3,[11] suggests rich discussions of BSP-related uncertainties at the FOMC meetings, when the tapering of asset purchases was postponed from September to December 2013.

In this section, first, we illustrate the perceived risk management response to BSPU: a positive and significant response of the expected size of SOMA to BSPU shocks. Second, following the methodology of Kim, Laubach, and Wei (2023) (henceforth KLW), we use a proxy SVAR with external instruments to estimate the impact of shocks to the first and second moments of BSP. Finally, to isolate the response of the economy to BSPU shocks alone, we use the estimated IRFs to build a counterfactual in which the endogenous response of the first moment to a BSPU shock is completely offset. In other words, we analyze the macroeconomic outcomes in the absence of a risk management response to BSPU.[12]

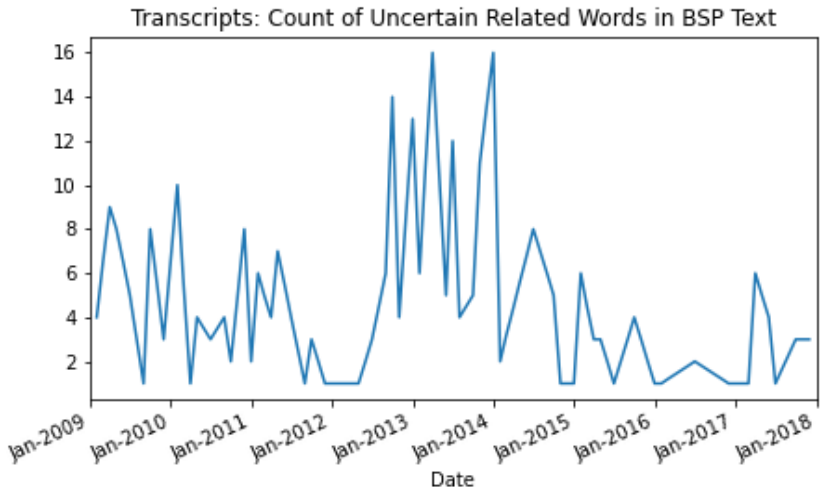
[9] See for instance Bullard (2021) and Evans et al. (2015)

[10] For a detailed discussion of these two episodes see Section 4 of D'Amico and Seida, forthcoming.

[11] We apply to the FOMC transcripts the same procedure described in Section 2, capturing the frequency of uncertainty-related words within the context of BSP-related sentences.

[12] This approach is similar in spirit to the fiscal policy scenarios in Mountford and Uhlig (2009) and the fully-credible forward guidance scenario in D'Amico and King (2023).

Figure 3. Uncertainty-related words in the BSP context in FOMC transcripts



Panel depicts the count of uncertain words within the context of Balance Sheet Policy related words in the transcripts of the FOMC meetings.

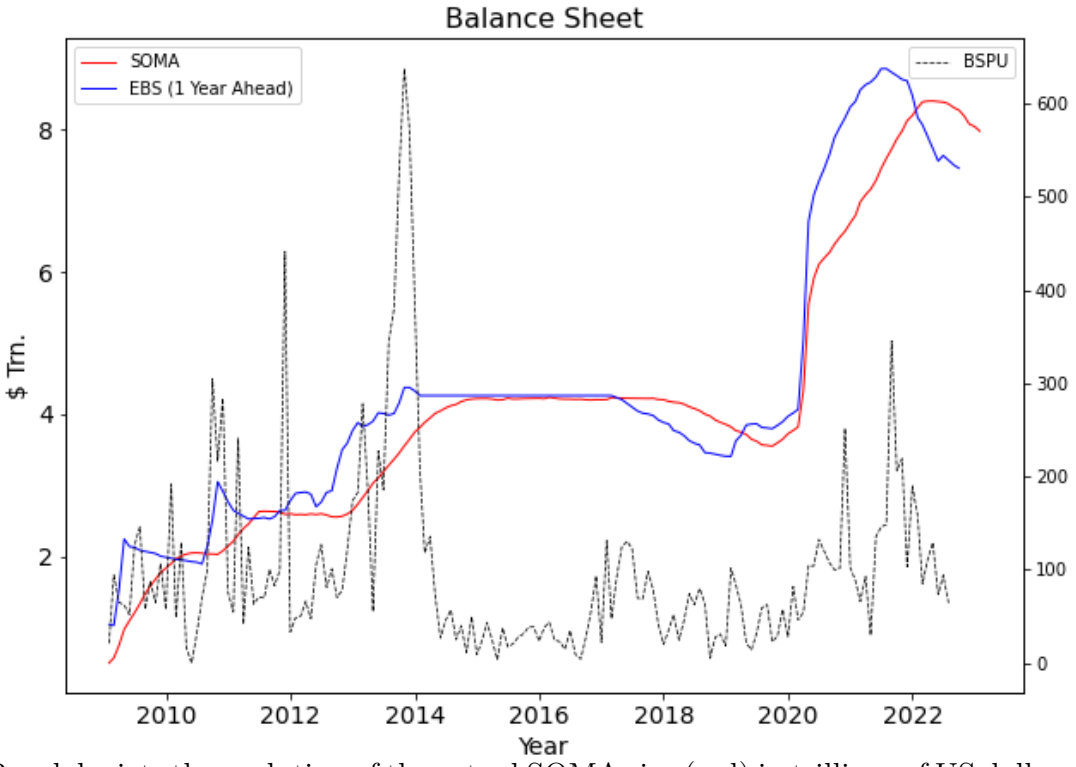
3.1 The interaction between the first and second moment of BSP

Since we are interested in estimating the effect of BSPU on financial variables and the broader economy, we have to first understand how uncertainty about BSP interacts with expectations about BSP. To this end, we start with estimating a VAR specification very similar to KLW, who study the macroeconomic impact of BSP expectations rather than the uncertainty around those expectations. We also use their measure of expected BSP: the one-year-ahead expected size of SOMA, constructed from the SPD, which we extend to 2022.[13] Importantly, the set of investors from which we derive the measures of expectations and uncertainty about the BSP are very similar, that is, the primary dealers.

The actual and expected size of the SOMA portfolio are plotted in Figure 4 together with the BSPU index. It is evident that significant changes and turning points in BSP expectations are associated with greater variation in the BSPU index.

[13]For a detailed description of this variable see KLW. We are very grateful to the authors for sharing their data with us.

Figure 4. One-year-ahead expected SOMA Size and BSPU



Panel depicts the evolution of the actual SOMA size (red) in trillions of US dollars, the one-year-ahead expectation of the SOMA size (blue), and the BSPU index (black dotted line) whose units are reported on right vertical axis.

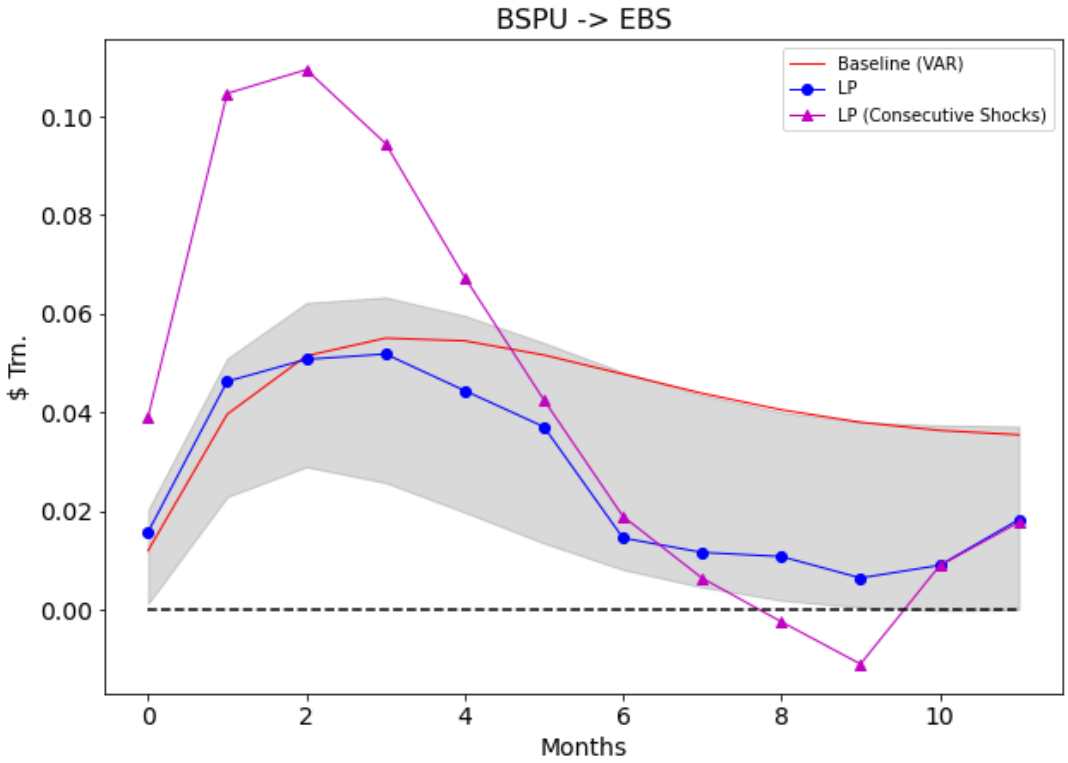
Before diving into the proxy SVAR with external instruments, which we describe in the next section, here we use some of the estimated IRFs to illustrate the perceived risk management response to BSPU shocks. Our sample is monthly, starts in January 2000 and ends in February 2020 (rather than 2022) to avoid the Covid period, which exhibited extreme movements in key macroeconomic variables. Our VAR specification includes the following variables: the logarithm of industrial production (IP), the logarithm of the consumer price index (CPI), BSPU index, the one-year-ahead expected size of SOMA (EBS), the excess bond premium (Gilchrist and Zakrajsek, 2012), the expectation and term premium components of the nominal 10-year Treasury yield,[14] and the duration of the US Private MBS portfolio.[15] This last variable has been included to account for forms of BSP that do not affect the size

[14]The decomposition of the 10-year nominal Treasury yield is obtained from the dynamic term structure model of D'Amico, Kim, and Wei (2018). We have also estimated the VAR using the decomposition for the 5-year nominal Treasury yield and obtained very similar results.

[15]All the data are obtained from Haver, with the execption of the MBS Duration data, which is obtained from Bloomberg.

of the SOMA portfolio but do affect its duration and therefore the private duration left in the market. Further, it allows us to account for amplifying effects due to convexity hedging, which might have played a role in some of the largest reaction to unexpected monetary policy changes (e.g., Perli and Sack, 2003). Importantly, since BSP is considered particularly effective on term and risk premia, it is possible that BSPU affects the expectation and term premium components of longer-term yields somewhat differently and we want to allow for this possibility.

Figure 5. IRFs of Expected BSP to a one-standard-deviation BSPU Shock



The red lines depicts the VAR IRF, the blue dotted line depicts the Local Projections IRF, and the purple line with triangles depicts the IRF obtained using the methodology of Diercks et al. (forthcoming). The grey-shaded area marks 68% confidence bands around the VAR IRF, computed using moving block bootstrap.

The red line in Figure 5 is the estimated IRF of the one-year-ahead expected size of SOMA to a positive one-standard-deviation BSPU shock, along with 68% confidence bands computed using moving block bootstraps (grey shaded area). One-year-ahead expectations about BSP react at impact and reach a peak of about $55 billions after 4 months. As a term of reference, the increase in the BSPU index during the taper tantrum episode is equivalent to a nearly 8-standard-deviation shock, implying that the expected size of SOMA one year

ahead should have increased on average by about $440 billions. Interestingly, following the increase in BSPU during the taper tantrum, the one-year-ahead expected size of SOMA reported in the October-2013 SPD increased by about $300 billions from the previous survey.

The estimation using a VAR imposes linearity on the system. However, as discussed in Diercks, Hsu, and Tamoni (2024), there could be higher order effects involving uncertainty shocks, especially in the case of consecutive shocks of the same sign, which a simple VAR is not fit to capture. Therefore, we re-estimate the same IRF using Jorda (2005) Local Projections (LP), and the LP method of Diercks, Hsu, and Tamoni (2024), in which the BSPU shock is interacted with an indicator that takes a value of one if the current and prior shock are both positive. As shown by the blue line, the IRF obtained with the conventional LP method tracks closely the SVAR IRF for the first 4 months but is less persistent. In contrast, the LP IRF that accounts for the amplification due to consecutive BSPU shocks (purple line) exhibits a peak reaction that is almost twice as big and lies outside the VAR confidence bands for the first 5 months of the forecasting period.

This is extremely relevant because some of the largest spikes in the BSPU index are due to consecutive BSPU shocks of the same sign. For instance, according to our index, the taper tantrum episode in characterized by a sequence of several positive shocks to the uncertainty about BSP. Hence, in these cases, the endogenous response of the first moment to the second moment of BSP could be very large and should not be ignored. In general, as depicted in Figure 5, even in the case of a single BSPU shock, investors seem to expect some risk management response by the Fed, and such response does not seem to be trivial and is quite persistent.

Importantly, since the perceived risk management response implies that, following a positive BSPU shock, the expected size of the SOMA portfolio increases quickly, and KLW show that such increases stimulate the economy by significantly reducing longer-term yields, we have to account for this endogenous response if we want to isolate the effects of BSPU shocks.

3.2 Isolating the response to BSPU

Isolating the response of the economy to BSPU shocks requires estimating this response in the absence of a perceived Fed's risk management approach to BSP uncertainty. This type of approach is often considered a prudent form of monetary policy as it has the purpose of alleviating the consequences of uncertainty by offsetting some of its potential effects. Since in the context of higher BSPU a perceived risk management approach entails an increase in the expected size of SOMA, to offset its impact we first need a well identified response

of the economy to EBS shocks. KLW provide a methodology based on proxy SVAR with external instruments to estimate IRFs to EBS shocks. We defer to their paper for a detailed description of this methodology and provide here a brief description.

The key novelty of their estimation strategy is to use the high-frequency LSAP factor introduced by Swanson (2021) to identify shocks to EBS. They have extended this factor to include intraday yield changes not only around FOMC announcements, but also around selected Fed official speeches and several FOMC-related news articles (see KLW online appendix for the complete list of events). Since their LSAP factor ends in 2015, we have spliced it with the LSAP factor from Jayawickrema and Swanson (2023) to extend it to 2020.[16] Recall that under the methodology of Swanson (2021), the LSAP factor is orthogonal to the target-rate and forward-guidance factors.

Further, since before 2009, BSP was not an active monetary policy tool, similarly to KLW, we extend the EBS measure and BSPU index back to 2000 by assuming that those variables equal zero. It is important to extend the sample to the pre-ZLB period to better identify the historical relationship between the macro and financial variables. At the same time, we found difficult to extend the sample further back than 2000 because having two variables equal zero for the majority of the sample period creates collinearity issues. The coefficients on the equations that determine the non-BSP variables are calculated over the entire sample (2000 to 2020), as those equations are not directly affected by the restrictions on the two BSP measures. We only use observations in and after December 2008 when estimating the two equations that determine EBS and $BSPU$. We use the reduced-form residuals from the post-December-2008 period when estimating the variance-covariance matrix. And, we apply post-December-2008 instruments to post-December-2008 residuals to identify shocks of interest.

Table 1 summarizes the results from the regressions of the first-stage VAR residuals on the LSAP factor, which test the strength of this instrument. The F-statistic from the first column, which is well above the recommended threshold of 10, suggests that, also in our sample, the LSAP factor is a strong instrument for EBS. Since in our proxy SVAR we have two variables related to BSP, we can estimate the IRFs to EBS shocks under the additional identifying assumption that the external instrument is correlated only with EBS shocks but not with BSPU shocks. This is not necessarily an innocuous assumption as it implies that any effect of BSP (FOMC announcements, Fed official speeches, etc..) on the BSP instrument will be attributed to the EBS shocks but not to the BSPU shocks. However, as shown in the second column, we find that the BSPU residuals are not significantly correlated with the external instrument for EBS shocks and that the F-statistic is extremely low, which

[16] We are very grateful to the authors of both studies for providing us with their LSAP factors.

alleviate concerns related to the exclusion restrictions.

Table 1. First-Stage Instrument Test

	EBS	BSPU
LSAP Factor	0.044**	-8.562
	(0.009)	(7.610)
Obs	135	135
R^2	0.143	0.009
Adj. R^2	0.136	0.002
F-stat	22.124	1.266

[1] Standard errors are in parentheses.
[2] (+) p<0.10, (*) p<0.05, (**) p<0.01.

Since the response of the economy to shocks to the first moment of BSP is not our focus, we report in Appendix D the IRFs to EBS shocks using the proxy SVAR with the LSAP factor as an external instrument. Overall, the estimated responses are a bit larger than those reported in KLW and are all statistically significant. In our sample, positive EBS shocks (i.e., BSP easing) seem to be more stimulative as the 10-year nominal term premium and excess bond premium are a bit more sensitive to these shocks. These results can be due to the different sample period or to the slightly different VAR specification. It obviously includes the BSPU index, which briefly declines in response to BSP easing, private MBS duration, and the expectation and term premium component of longer-term yields separately.

Once we have identified the economic reaction to EBS shocks, we can use it to offset the perceived risk management response to positive BSPU shocks, shown in Section 3.1, and hence capture the IRFs to BSPU alone. This requires to estimate first, within the same proxy SVAR, the economic reaction to BSPU shocks, and then build a counterfactual in which we "subtract" from this reaction the economic expansion induced by the endogenous increase in EBS (i.e., the perceived risk management response). The counterfactual is implemented by introducing a sequence of negative EBS shocks of the same size as the changes in the baseline EBS IRF, and then let the economy simply follows the VAR dynamics.

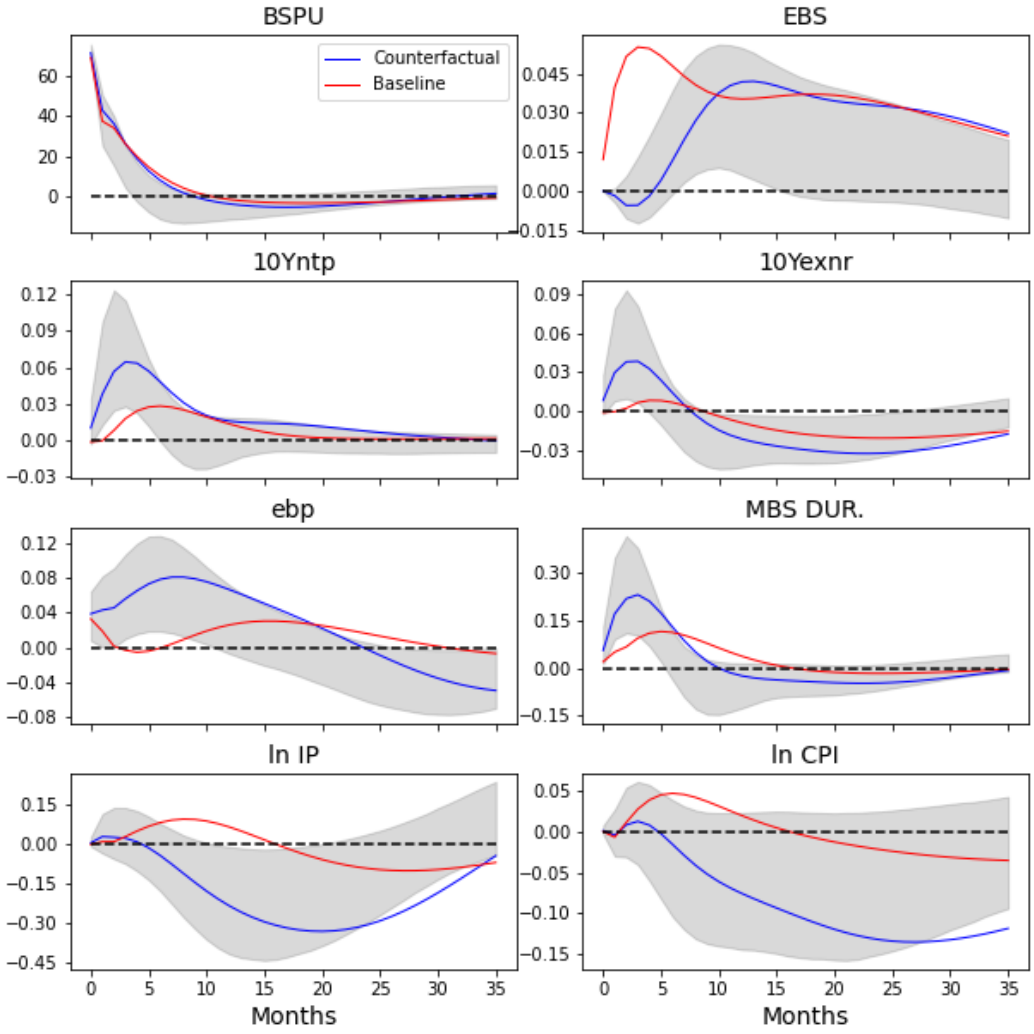
In Figure 6, we report in red the baseline IRFs to BSPU shocks (Appendix E reports the confidence bands around these IRFs). In practice, to estimate these responses, we use the procedure implemented in D'Amico and Farka (2011). Specifically, we purify the reduced-form residuals from the contemporaneous reaction to EBS shocks. This consists of taking the

residuals from the regressions of the reduced-form residuals on the LSAP factor from 2009 to February 2020, and then apply the Cholesky decomposition to the variance-covariance matrix of these purified residuals with the following recursive structure: log of IP, log of CPI, BSPU index, excess bond premium (ebp), expected 10-year Treasury yield (10Yexnr), 10-year term premium (10Yntp), private MBS duration, and EBS. This variable can now be ordered last as, by construction, all the other variables in the system have been already purified of their contemporaneous reaction to EBS and therefore can respond to it with one-month delay.

In contrast, the blue lines depict the IRFs under the counterfactual scenario in which we offset the EBS endogenous response. We simulate the VAR and corresponding counterfactual scenario 10,000 times using the approach of moving block bootstrap (MBB) with a block length of 1 to generate the 68 percent confidence intervals, marked by the grey-shaded areas. We use this method because Jentsch and Lunsford (2019) pointed out that this bootstrap is more appropriate in our setting. In Appendix F, we also report the results using the wild bootstrap (with a multiplier of 1 or -1 with equal probability applied to both the reduced-form residuals and the instrument). Further, in the counterfactual, the statistical and model uncertainty about the response to EBS shocks and the response to BSPU shocks might compound with each other.

In the upper right panel of Figure 6, it is possible to observe the baseline response of the expected Fed balance sheet to a BSPU shock (which is identical to the risk management response reported in Figure 5) and its evolution under the counterfactual scenario. In the latter case, as shown in the second row, both the term premium and expectation component of the 10-year yield increase immediately and reach a peak of about 6.4 and 3.8 basis points, respectively, within the first few months. Also the excess bond premium follows a similar pattern, with a peak of about 8 basis points after 6 months. Similarly, private MBS duration increases substantially. Following this significant tightening in financial conditions, IP starts declining after 5 months and bottoms out at about -0.3 percentage points after one year. The response is statistically significant after nine months. In contrast, the decline in the CPI level is not statistically significant.

Figure 6. IRFs to BSPU shocks with and without EBS endogenous response



IRFs to a positive 1 standard deviation shock in BSPU with and without counterfactual. Grey-shaded areas mark 68% confidence bands, generated with moving block bootstrap.

Overall, when we isolate the IRFs to BSPU shocks, it is possible to observe that in the absence of a perceived risk management response, an increase in BSPU has economic effects very similar to those of a monetary policy tightening shock. To provide a stark illustration of this point, in the next section, we estimate the economic response to a BSPU shock similar in size to that of the taper tantrum episode. However, differently from that episode, we do not allow for an endogenous increase in the one-year-ahead expected size of SOMA.

4 The role of BSPU in the Taper Tantrum

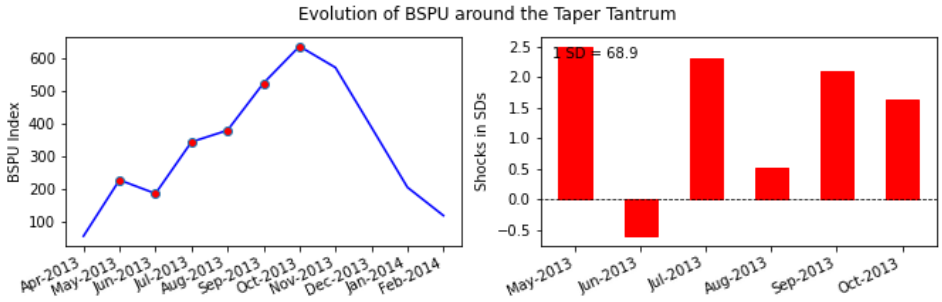
To quantify the role of BSPU in the taper tantrum episode, we use the SVAR estimates to evaluate the economic impact of a BSPU shock equivalent to the entire spike in the BSPU index observed during that episode—which is plotted in the top-left panel of Figure 7. It can be noted that, since a one-standard-deviation shock to the BSPU index is equal to about 62 units, the BSPU shock realized during the taper tantrum is almost a 8-standard-deviation shock. Hence, next, we estimate the response to such shock by scaling up the baseline IRFs and related counterfactual.

The blue lines in Panel (b) of Figure 7 show that, in the absence of the perceived risk management response that took place following the initial increase in BSPU, the 10-year yield would have increased by about 86 basis points due only to higher BSPU, and the excess bond premium would have increased by about 69 basis points. In turn, according to the counterfactual estimates, those extreme responses of the longer-term yield and corporate risk premium would have caused an overall contraction of about 3 percentage points in log IP after 18 months year.

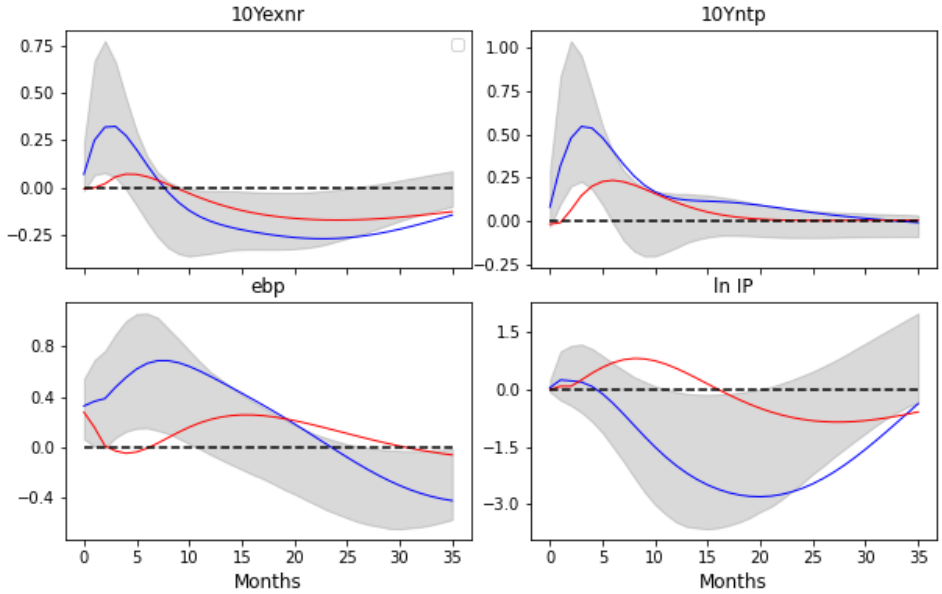
However, since in September 2013, the tapering of asset purchases was postponed and the expected size of SOMA increased by about $300 billions, an amount equivalent to the first Treasury LSAP, the observed increase in the 10-year yield that is attributed to BSPU amounts to about 25 basis points (out of 108 that occurred between May and November 2013), nearly a quarter of the total change. As a result, the estimated IRF of IP fluctuates around zero rather than declining significantly. The contrast between the blue and red lines, not only shows that BSPU played a big role in the taper tantrum episode, but also suggests that the perceived risk management response avoided large contractionary effects. In other words, the Fed's risk management approach to BSP seems to have been successful.

Finally, it should be noted that the significant increase in the expectation component of the 10-year yield (in the counterfactual scenario) suggests that an increase in BSPU not offset by a risk management approach to BSP, might signal a future policy-rate tightening (or liftoff), therefore increasing policy rate expectations at longer horizons.

Figure 7. The Taper Tantrum



(a)



(b)

Panel (a) depicts the evolution of BSPU from April-2013 to February-2014 and highlights the shocks in 6 months of the Taper Tantrum. Panel (b) depicts the cumulative effect of these shocks on the economy.

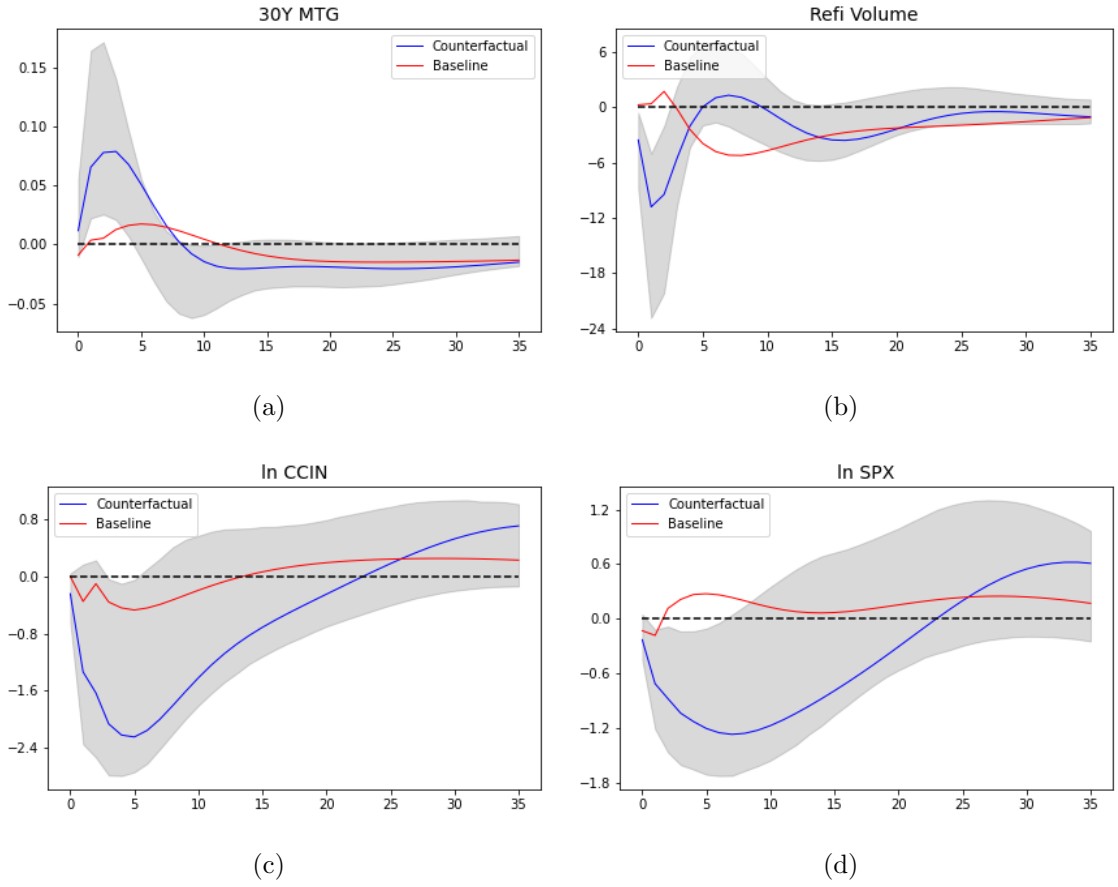
5 Additional transmission channels of BSPU

To investigate further how BSPU shocks propagate through the economy, in Figure 8 we plot the IRFs of additional variables, when they are added to the baseline VAR one at a time to avoid estimating large VARs. In particular, we consider the 30-year mortgage rate, stock

market prices (S&P500 index), refinancing volumes, and consumer confidence[17] to analyze the pass-through of BSPU shocks to private borrowing costs and profitability.

Similarly to a quantitative tightening shock, mortgage rates rise by an amount similar to longer-term Treasury yields (8 basis points at peak), the refinance volume falls by approximately 10%, consumer confidence declines quickly and so does the stock market index, although the IRF for consumer confidence is hardly significant. Overall, these patterns are very similar to those observed in the refinancing channel of QE (Di Maggio et al, 2020) but in reverse.

Figure 8. IRFs of key additional variables to BSPU shocks



(a) (b)

(c) (d)

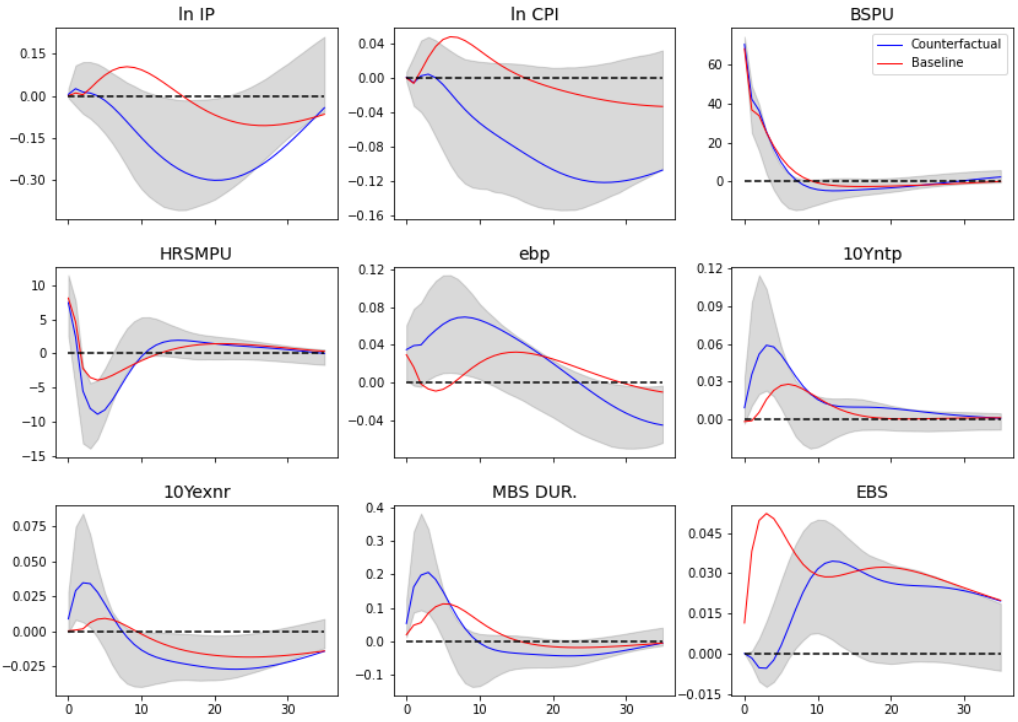
IRFs to a positive 1 standard deviation shock in BSPU with and without counterfactual. Grey-shaded areas mark 68% confidence bands, generated with moving block bootstrap.

[17] All data from Haver.

6 Robustness to alternative policy uncertainties

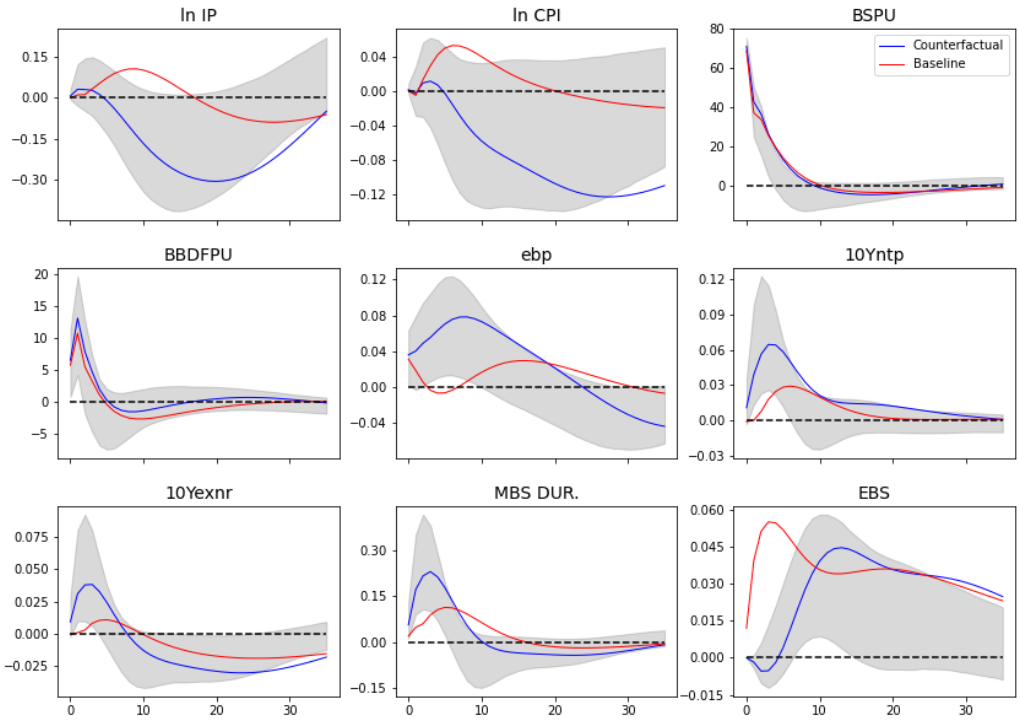
In this section, we analyze whether the baseline IRFs shown in Figure 6 change when we include as additional control either the HRS monetary policy uncertainty (MPU) index or BBD fiscal policy uncertainty (FPU) index. Because BSPU is part of the broader economic policy uncertainty, we order BSPU before either BBD-FPU or HRS-MPU, thus allowing shocks to BSPU to affect monetary and fiscal policy uncertainty contemporaneously. By having BBD-FPU or HRS-MPU in the SVAR, we are going to estimate the residual effect of policy uncertainty specific to the Fed's balance sheet. Overall, as illustrated in Figure 9 and Figure 10, the IRFs remain very similar to those estimated in our baseline specification.

Figure 9. IRFs to BSPU shocks when controlling for HRS-MPU



IRFs to a positive 1 standard deviation shock in BSPU with and without counterfactual. Grey-shaded areas mark 68% confidence bands, generated with moving block bootstrap.

Figure 10. IRFs to BSPU shocks when controlling for BBD-FPU



IRFs to a positive 1 standard deviation shock in BSPU with and without counterfactual. Grey-shaded areas mark 68% confidence bands, generated with moving block bootstrap.

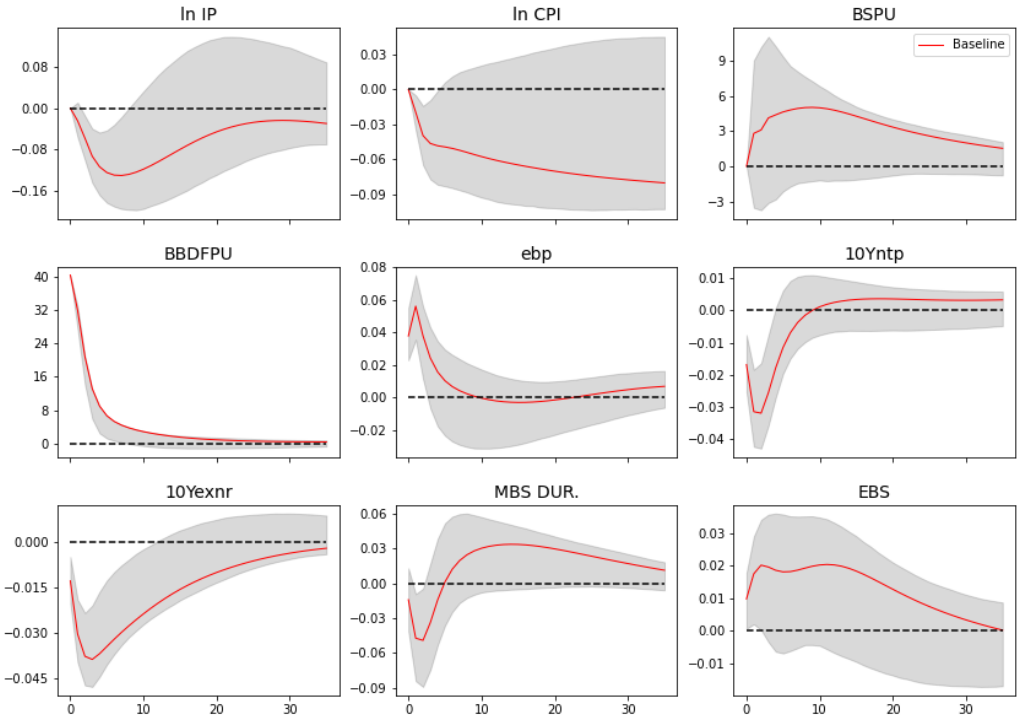
7 Comparison to other policy uncertainties' effects

In this section, we try to understand whether the economic effects of BSPU are different from those of both FPU and broader MPU.

To begin with, we contrast the effects of BSPU to those of FPU within the same SVAR model. As shown in Figure 11, the IRFs to a FPU shock are quite similar to those that would be observed in response to uncertainty about a demand shock (Basu and Bundick, 2017). That is, fiscal policy shocks behave like demand shocks in that they move payoffs on risk-free nominal bonds in the opposite direction of real activity. Higher FPU therefore increases the likelihood that nominal bonds will act as a hedge and experience good returns in bad states of the world, reducing the term premium. At the same time, since corporate default risk rises when real activity falls (and vice versa), fiscal policy shocks send payoffs on risky bonds in the same direction of real activity. Thus, higher FPU increases the likelihood that risky

bonds will experience bad returns in bad states of the world, and risk-averse investors will require compensation for that risk.

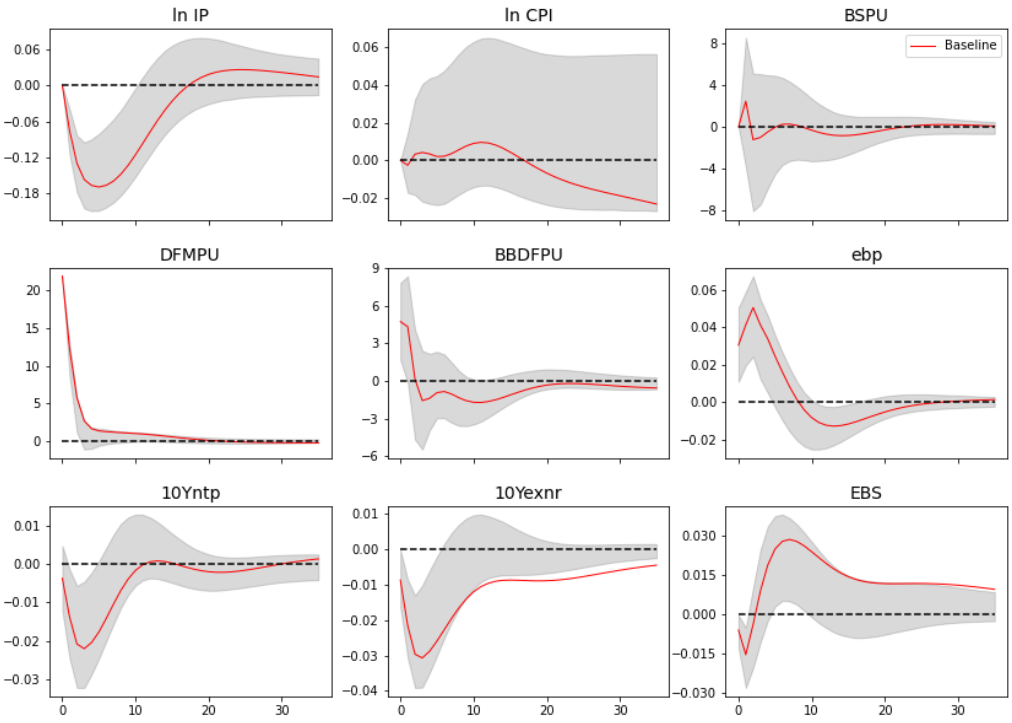
Figure 11. IRFs to BBD Fiscal Policy Uncertainty Shocks



IRFs to a positive 1 standard deviation shock in FPU. Grey-shaded areas mark 68% confidence bands, generated with moving block bootstrap.

To understand whether BSPU and broader MPU work through similar transmission mechanisms, Figure 12 summarizes the effects of shocks to broader MPU, measured by our "All-Fed" MPU index (DF-MPU) shown in Appendix C. We find that post-2008, broader uncertainty about monetary policy also has an economic impact similar to that of uncertainty about a demand shock, as in the case of FPU. Further, in this case, the expected size of the SOMA portfolio initially declines rather than increasing. Overall, these results are quite similar to those estimated by Husted, Rogers, and Sun (2019) using the external instruments approach, despite the fact that our sample and specification are quite different.

Figure 12. IRFs to Broad Monetary Policy Uncertainty Shocks



IRFs to a positive 1 standard deviation shock in "All Fed" MPU, described in Appendix C. Grey-shaded areas mark 68% confidence bands, respectively, generated with moving block bootstrap.

8 Conclusions

We develop a new measure of investors' uncertainty about Federal Reserve balance sheet policy (BSP). Our measure reflects the average opinion of large dealers who tend to be careful Fed watchers and hence might be better informed than the marginal investor. Additionally, large dealers convey their own uncertainty to their clients and therefore influence the view of the broader market.

We compare our measure of BSP uncertainty to existing proxies of uncertainty about interest rates, conventional monetary policy, fiscal policy, and economic policy more broadly. Fluctuations in our uncertainty index are quite different from those of market-based indicators of interest rate uncertainty and from other indicators of monetary policy uncertainty, as our index is focused on the Fed's balance sheet. This tool is more novel than other Fed's policy tools and is at times characterized by a higher degree of uncertainty.

We find that an increase in BSP uncertainty strongly affects longer-term nominal Treasury yields and private borrowing costs, pushing them significantly higher. As a result, it has contractionary effects on IP and CPI, although the latter is not statistically significant. Overall, a positive shock to BSP uncertainty seems to transmit to the economy in a fashion very similar to a monetary-policy tightening shock. This is quite different from the transmission mechanism of other forms of policy uncertainties in the post-2008 sample.

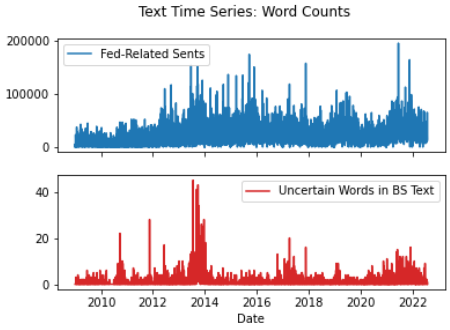
Importantly, our estimates can be used to quantify the role of BSPU in the taper tantrum episode. According to the change registered in our BSPU index, that episode was equivalent to a 8-standard-deviation shock that increased longer-term Treasury yields by 25 basis points, but could have increased them by 90 basis points in the absence of the Fed's risk management response. In other words, if the Fed did not postpone the tapering of asset purchases and therefore increase the size of its balance sheet, the negative impact of the taper tantrum shock on the economy could have been significant.

Our findings indicate that, since 2009, BSP uncertainty has played an important role, suggesting that explicit forward guidance about the Fed balance sheet path might be warranted. The lack of a historical BSP "rule" heightens the need for guidance about the criteria driving BSP decisions. Further, more flexible forms of BSP (e.g., open-ended) might create more uncertainty and therefore require more guidance. This complicates the trade-off between flexibility and predictability.

A Summary Text Statistics for the BSPU Index

We use a sample of 5 dealers that runs from Jan-2009 to August-2022:

Banks	5
Fed NLs	120,060
Words in all Fed-tagged NLs	1,373,535,569
Words in Fed Sentences	107,186,710
Words in BS Sentences	14,983,728
Uncertainty Words in all Fed-tagged NLs	220,998
Uncertainty Words in Fed Sentences	42,621
Uncertainty Words in BS Sentences	5,398



B External validation of major spikes in BSPU index

- Oct-2010: "If the Fed moves forward with QE next week, the **uncertainty** over the quantity of purchases will increase the importance of each data point in the future."
- Nov-2011: "...impact **uncertainty** surrounding asset purchases is larger than for funds rate changes... the effects of asset purchases are around twice as **uncertain** as those of funds rate changes... the FOMC's decision not to opt for additional asset purchases at the November meeting is well explained with the **uncertainty** surrounding their effects."
- Sep-2013: "the surprising decision to leave asset purchases unchanged has confused investors about fed communication strategy and increased **uncertainty** about the path of future policy moves... the outlook for asset purchases is more **uncertain** now as the definition of 'substantial improvement' in the labor market remains vague."
- Apr-2017: "The FOMC is set to undergo substantial personnel changes in the next 18 months. If the Committee formally agrees on a plan this year, it will be hard (but not impossible) for future Fed appointments to change the plan in coming years... agreeing on a strategy for balance sheet normalization this year should remove one source of **uncertainty** hanging over financial markets."
- Nov-2020: "Fed buying of corporate bonds will end in 2020, which together with a shifting legislative and regulatory backdrop creates **uncertainties**."... "In a letter to the Fed on November 19th, the program was ended. Treasury secretary Mnuchin deferred to the interpretation of the CARES act suggesting the authority to purchase new assets expires on December 31, 2020"... "The seeming discord between Fed and

Treasury creates **uncertainties** which are negative, though it may also cement the Fed's resolve to enhance QE in December."

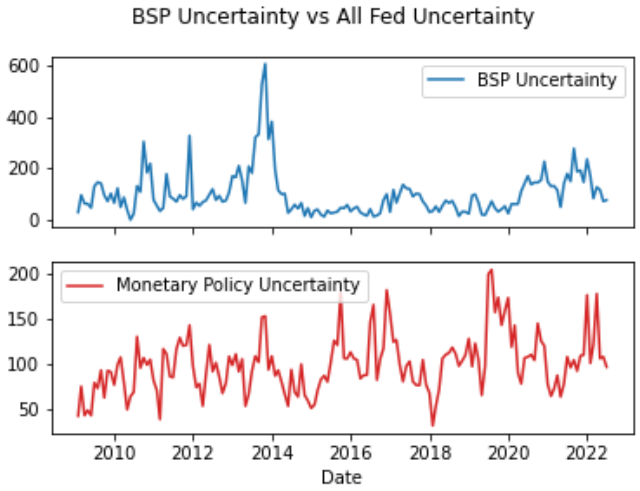
- Aug-2021: "Markets will need to contend with the Fed tapering in this **uncertain** backdrop and we expect the Fed to emphasize that tapering is not tightening and that it will not mechanically be followed by a hike in the policy rate... In our view, the main risk towards a much higher term premia comes from either the Fed falling behind the curve or a sharp increase in monetary policy **uncertainty**... if inflation remains high, it could lead to greater **uncertainty** regarding the Fed's path for tapering and rate hikes, which is likely to disproportionately impact small caps."

C Comparison to other proxies of uncertainty

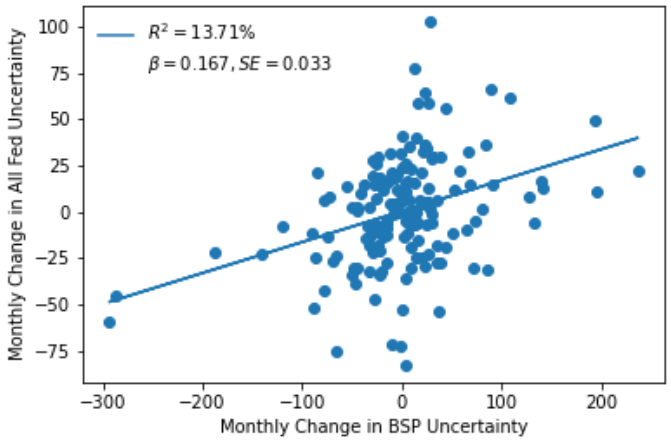
To better evaluate the information content of our BSPU index, we compare it to different proxies of monetary and fiscal policy uncertainty.

First, we construct a broader monetary policy uncertainty index, labeled "All-Fed" MPU index, by counting the number of uncertain words in all Fed-relevant text and normalizing it in the same way we normalized the BSPU index. This implies that BSPU forms one component of "All-Fed" MPU, but as shown in Figure 13 there are periods where conventional MPU dominates, like late-2015 around liftoff.

Figure 13. BSPU VS "All-Fed" MPU index



(a)

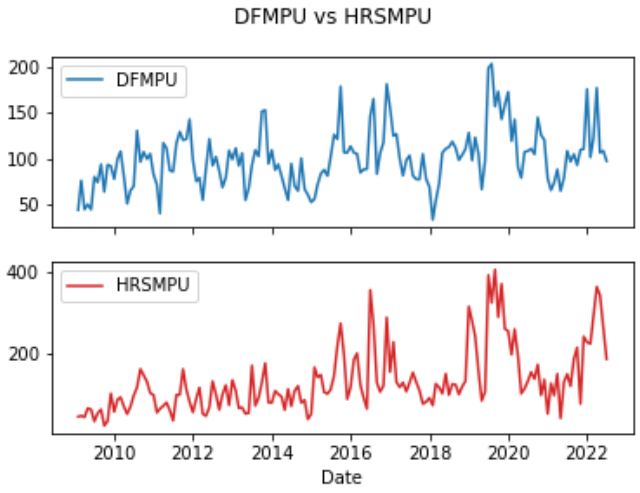


(b)

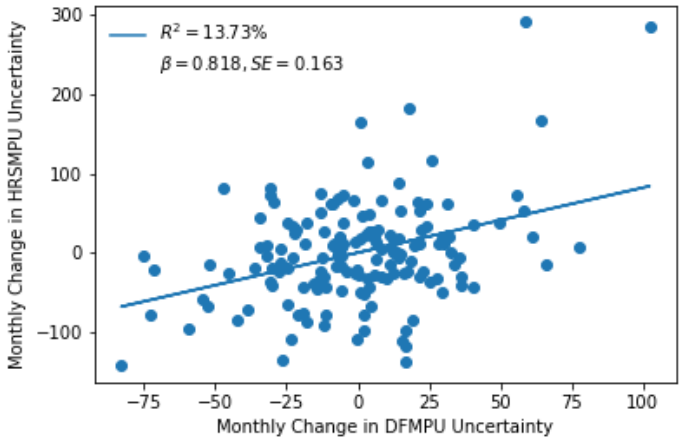
Panel (a) depicts a time series comparison of BSPU and "All-Fed" MPU. Panel (b) depicts a scatter plot of monthly changes in each.

Then we compare our All-Fed MPU index to the Husted, Rogers and Sun (2020, henceforth HRS) MPU Index constructed from newspaper articles. Our "all-Fed" MPU is distinct in a number of ways (most importantly in source and construction), but it is reassuring to observe that our MPU index and HRS-MPU Index behave similarly, as both are meant to capture broader monetary policy uncertainty and not just BSP uncertainty.

Figure 14. HRS-MPU VS "All-Fed" MPU



(a)

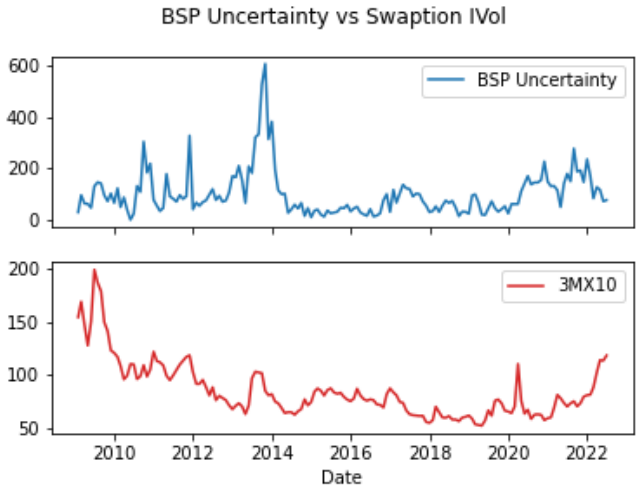


(b)

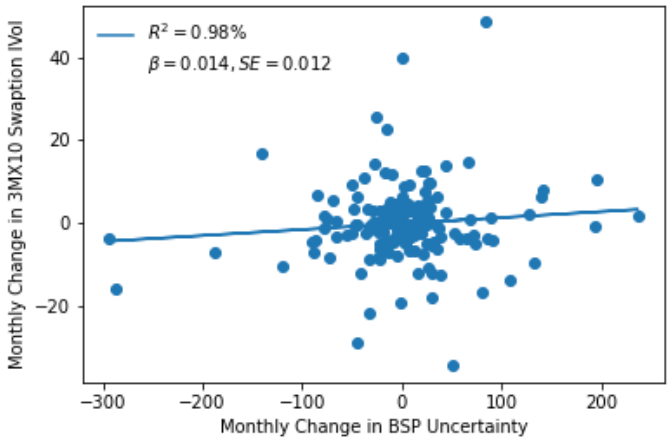
Panel (a) depicts a time series comparison of HRS-MPU and "All-Fed" MPU index. Panel (b) depicts a scatter plot of monthly changes in each.

Further, we also compare our BSPU index to market-based uncertainty about interest rates measured by implied volatilities derived from interest rate swaptions. In line with HRS (2020), we also find minimal relation to market-based measures of interest rates uncertainty. We believe this might indicate that risk premia and other sources of uncertainty are important drivers of changes in interest rate implied volatility. Moreover, at the ZLB, market-based implied volatilities are artificially compressed, and therefore might not necessarily be a strong proxy of monetary policy uncertainty.

Figure 15. BSPU VS 3-Month Interest Rate Implied Vol



(a)

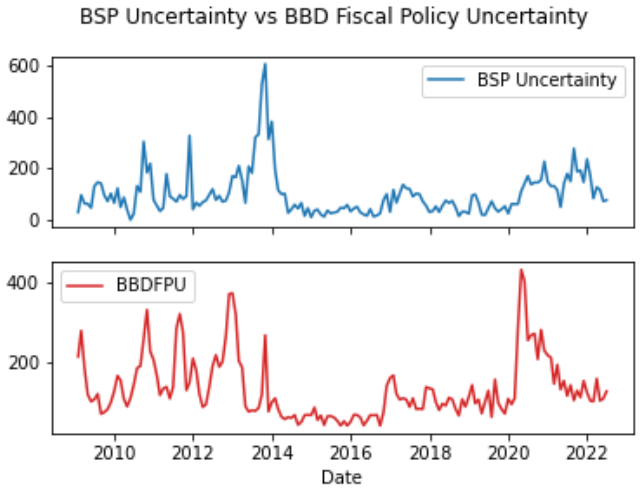


(b)

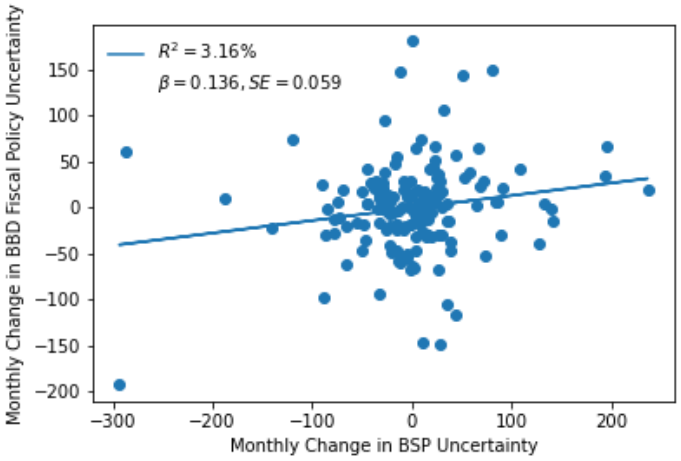
Panel (a) depicts a time series comparison of BSPU and the 3-month implied volatility on the 10-year rate from swaptions. Panel (b) depicts a scatter plot of monthly changes in each.

Finally, we also analyze how our BSPU index relates to proxies of fiscal policy uncertainty. Baker, Bloom and Davis (2016, henceforth BBD) use newspapers to derive measures of broader economic policy uncertainty, as well as monetary and fiscal policy uncertainty (FPU). It is easy to observe that even if the two indices are positively related, they are quite different because of our singular focus on the Fed's balance sheet.

Figure 16. BSPU VS BBD-FPU



(a)



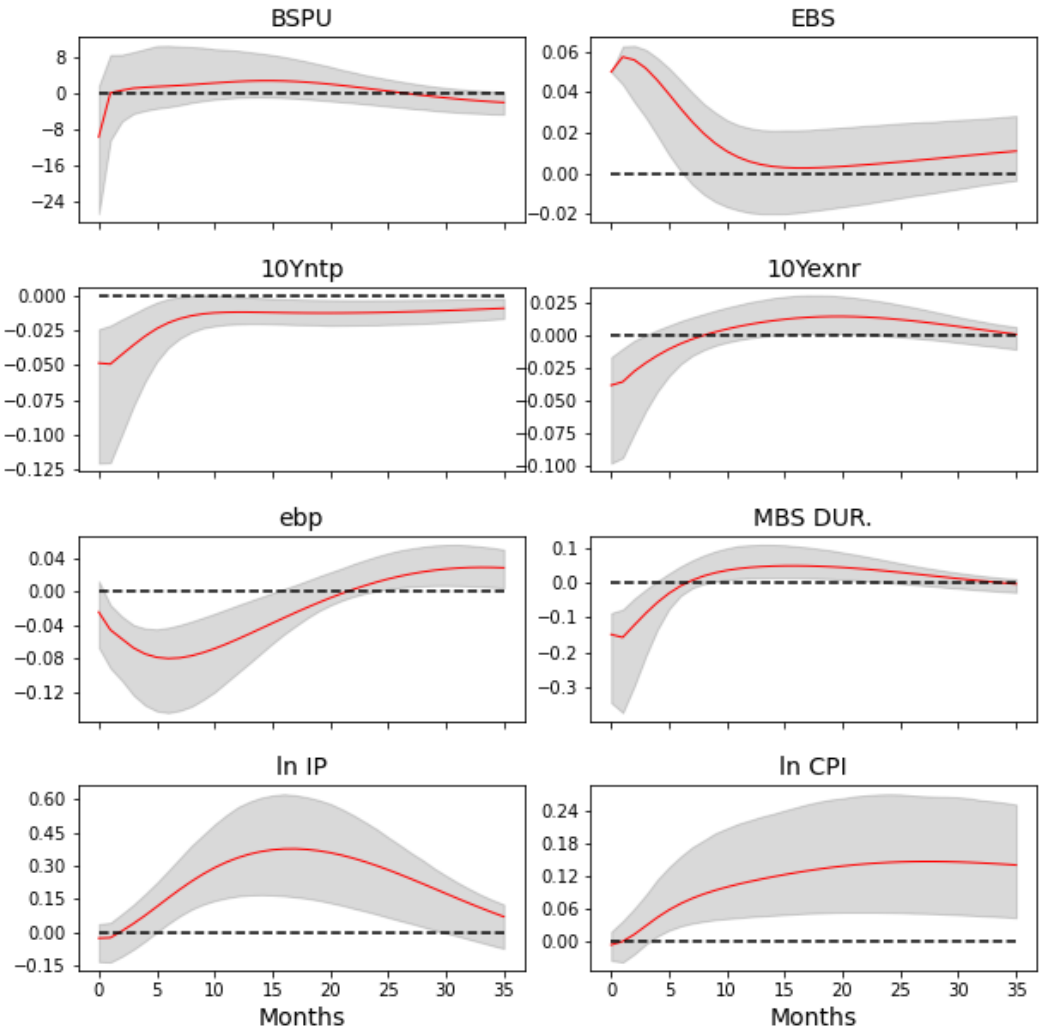
(b)

Panel (a) depicts a time series comparison of BSPU and the fiscal policy uncertainty measure of Baker, Bloom and Davis (2016). Panel (b) depicts a scatter plot of monthly changes in each.

In the rest of the paper, we use BBD-FPU as a way to control in part for broader economic uncertainty. We also employ the BBD-EPU index and obtain very similar results.

D IRFs to EBS shock using the KLW(2023) methodology

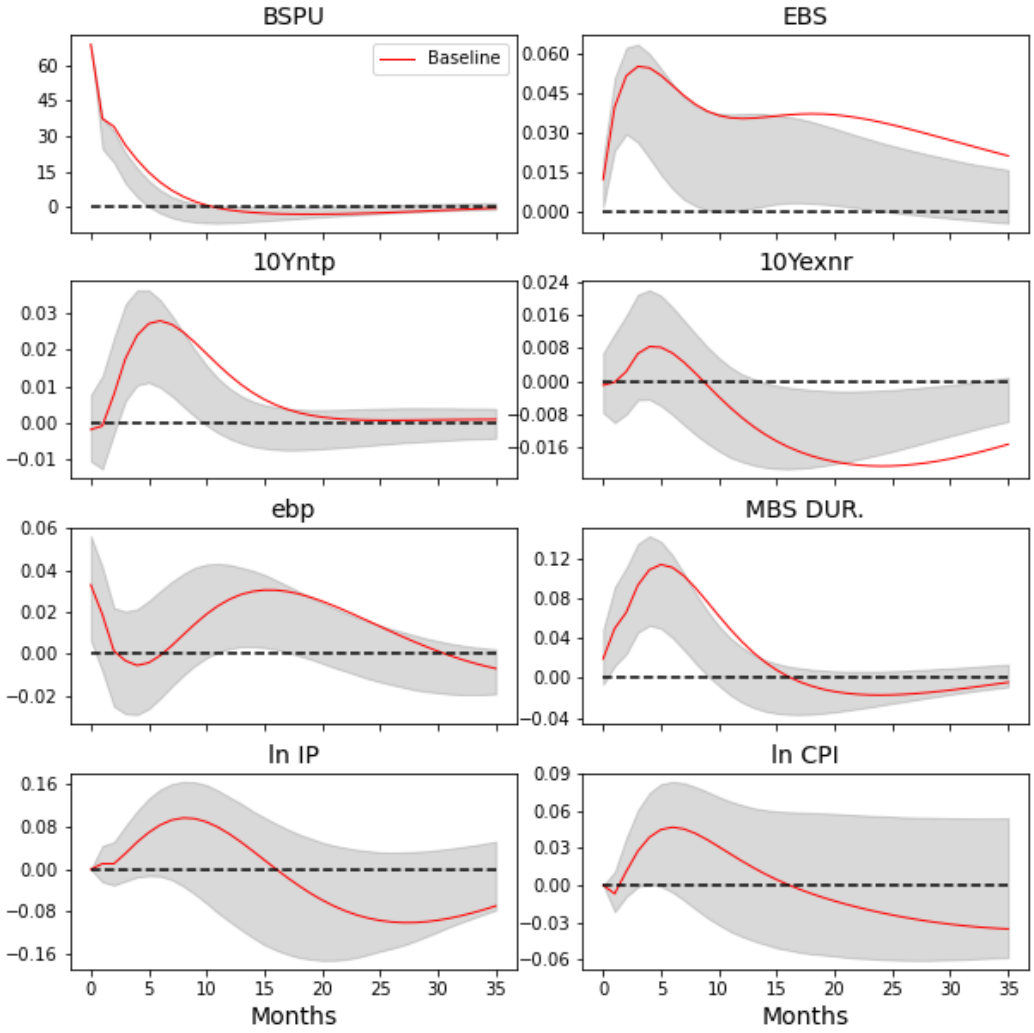
Figure 17. Impulse Responses to a one-standard-deviation EBS Shock



The red lines depict the IRF to 1 standard-deviation shock to the one-year-ahead expected size of the SOMA portfolio using the external instrument approach of Kim, Laubach, and Wei (2023). The grey-shaded areas mark 68% confidence bands generated with moving block bootstrap.

E Baseline IRFs to BSPU shocks with Confidence Intervals

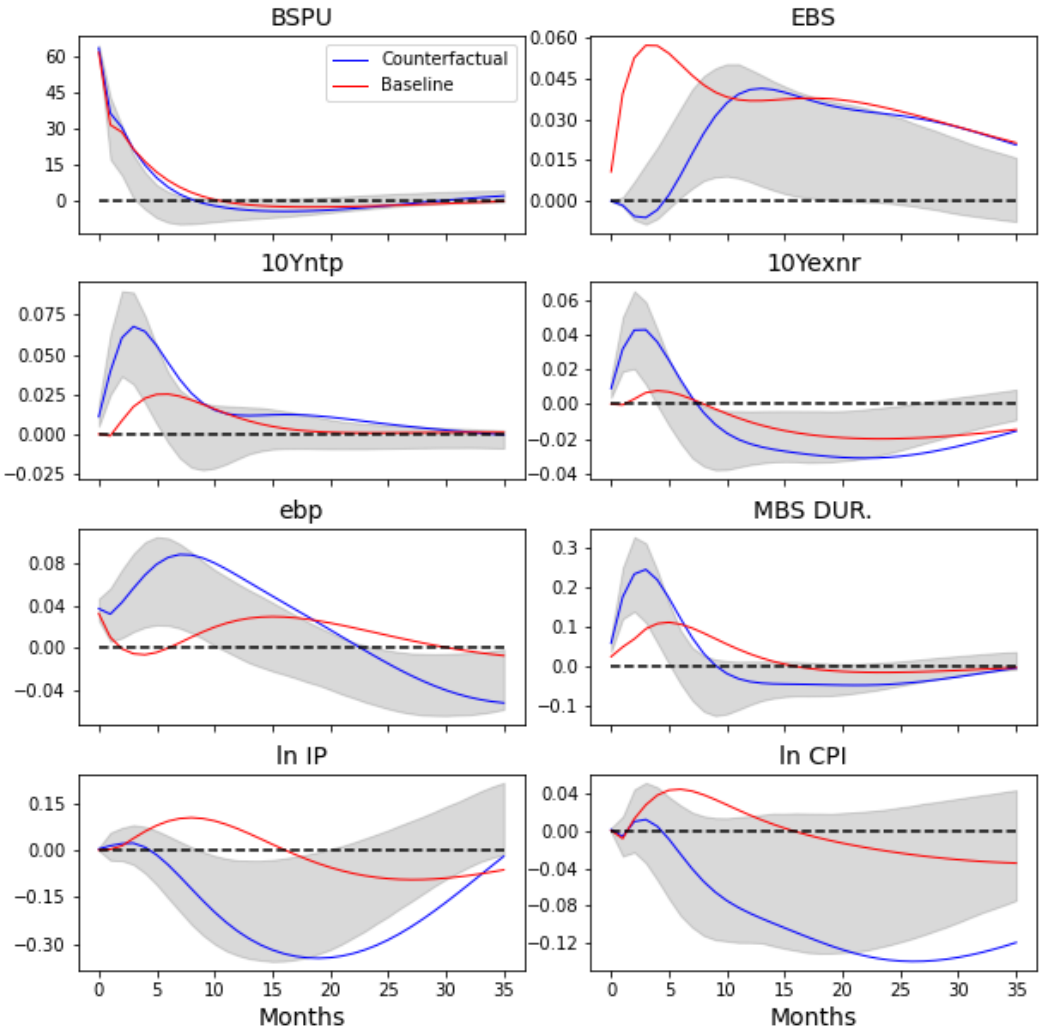
Figure 18. Impulse Responses to a one-standard-deviation BSPU Shock



The red lines depict the IRF to 1 standard-deviation shock to BSPU. The grey-shaded areas mark 68% confidence bands computed using bootstraps methods.

F Counterfactual IRFs to BSPU shocks with confidence intervals generated with wild bootstrap

Figure 19. IRFs to BSPU shocks with and without EBS endogenous response



IRFs to a positive 1 standard deviation shock in BSPU with and without counterfactual. Grey-shaded areas mark 68% confidence bands, computed using bootstrapping methods.

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