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FISCAL POLICY IN THE US: A NEW MEASURE OF UNCERTAINTY AND ITS RECENT DEVELOPMENT

by Alessio Anzuini[*] and Luca Rossi[*]

Abstract

We use the dispersion of the Federal Budget Balance forecasts from Consensus Economics to construct a new measure of fiscal uncertainty; constant horizon forecasts are obtained through mixture distributions. The scheme we propose has several advantages over previous uncertainty measures. First (as opposed to recent proposals) it results in a forward-looking measure, which implies that any sudden development in terms of an (un)expected fiscal stance is immediately incorporated in the series. Second, the measure is by construction a real-time one. Third, being completely model-free, it is not contaminated (inflated) by model uncertainty. Fourth, it is comprehensive in accounting both as regards the critical welfare component of public expenditure and in relation to taxes, i.e. it does not simply track uncertainty stemming from public consumption and investment. Fifth, as opposed to uncertainty indexes which can be interpreted only dynamically, our measure has an obvious intuitive point-wise interpretation. Interestingly, the inception of the Trump administration has led to unprecedented uncertainty shocks which have demonstrably put a non-negligible brake on the slow US recovery. More generally, we show that fiscal uncertainty shocks have clear recessionary effects. Furthermore, constraints on monetary policies during the ZLB have likely strengthened the recessionary effects of fiscal uncertainty shocks.

JEL Classification: C2, E3, O41.
Keywords: VAR, fiscal policy, uncertainty shocks.

Contents

1. Introduction 5
2. A forecast-based uncertainty measure 8
   2.1 Forecast data 8
   2.2 Mixture distributions 9
3. Fiscal Policy Uncertainty and the macroeconomy: a VAR approach 11
   3.1 Baseline results 11
   3.2 Uncertainty and the Trump administration 12
   3.3 Uncertainty and the zero lower bound 17
4. Concluding remarks 17
Appendix 19
References 20

[*] Bank of Italy, Economic Research and International Relations.

1 Introduction

Economic theory suggests that uncertainty shocks may be important in explaining economic fluctuations: firms may react to an increasingly uncertain environment by cutting back hiring and investment; financial intermediaries may become more reluctant to lend; households may increase their propensity to save[1]. Economic uncertainty takes many forms, and originates from several sources. In the current paper we focus on fiscal policy uncertainty (FPU). Fiscal policy may represent a source of uncertainty for economic agents for several reasons.

In countries with unsustainable public finances, households and firms may expect changes in future tax rates and/or expenditure programs (and therefore on crucial variables such as net profits, disposable income, etc.), but they may be unsure of the timing as well as of the magnitude of those changes.[2]

Even in countries where public finances are sustainable, FPU may be high if the political process is polarized and fiscal frameworks are weak (Kontopoulos and Perotti, 2002, Roubini and Sachs, 1989). In those countries, political uncertainty translates into FPU, because changes of government and switches in government coalitions can lead to unpredictable or erratic changes in fiscal policy.

Finally, even in stable and solvent countries with a solid fiscal framework, policy uncertainty shocks due to unexpected events can affect economic activity, leading to lower growth and employment by increasing precautionary savings and procrastinating investment.

The only two papers that look at fiscal uncertainty shocks for the U.S. are, to the best of our knowledge, Born and Pfeifer (2014) and Fernández-Villaverde et al. (2015)[3]. They proxy FPU with the time-varying volatility of the innovation of a fiscal reaction function[4].

The estimated fiscal policy rules discipline their quantitative experiments with the implicit assumption that past fiscal behavior is a guide to assessing current behavior. As acknowledged in Fernández-Villaverde et al. (2015) there are, at least, two alternatives to this approach. First is the direct use of agents expectations. This would avoid the problem that the timing of the estimated uncertainty and of the actual uncertainty that agents face might be different. Nonetheless, in their contribution they specify: "...to the best of our knowledge, there are no surveys

[1]See, among others, Bloom (2014).

[2]Theoretical discussion of the adverse effects of government's procrastination can be found in Gomes et al. (2012).

[3]For an application to the Italian economy see Anzuini et al. (2017).

[4]A similar methodology is adopted by Scotti (2013) and Jurado et al. (2015). Both papers aim at modeling macroeconomic volatility at large, not FPU.

that elicit information about individuals' expectations with regard to future fiscal policies (or, as in the Survey of Professional Forecasters, it is limited to short-run forecasts of government consumption)". As we will show, this statement is not entirely true and there are indeed surveys about the conduct of future fiscal policy which contain information that can be exploited to construct a measure of FPU. A second alternative would be to estimate a fully fledged business cycle model and to smooth out the time-varying volatility in fiscal rules. However, the size of the state space in that exercise would make such a strategy too onerous.

In the present paper, we opt for the first alternative. We therefore propose a new measure of FPU and study its effects on the US macroeconomic situation. In particular, we first estimate the standard deviation of the expected U.S. budget balance from Consensus Economics. Unfortunately, CE dose not provide the distribution of the forecasts for each forecaster so that what we measure is not the standard deviation of the subjective probability distribution but rather the standard deviation across forecasters, i.e. the dispersion (the cross-sectional volatility) of the forecasts, which we take as our proxy for FPU. Moreover, we are interested in recovering the standard deviation of the ratio of the expected U.S. budget balance to GDP. In order to do so, we extract one draw from the CE empirical distribution of the budget balance forecast, and a second one from the empirical distribution of the GDP forecast from the Survey of Professional Forecaster. We then take the ratio and calculate the standard deviation of the ten thousand replications for each t. As a second step, we feed a VAR model with this dispersion and analyze how a shock to this measure impacts the macro-economy. We find that an increase in FPU has a negative impact on the economy.

Our paper contributes to two different streams of the macroeconomic literature. First, the recent empirical research on the macroeconomics of uncertainty. As we already mentioned, uncertainty stems from several sources. Some papers have focused on stock-market-induced uncertainty, such as Bloom (2009), which uses peaks in stock market volatility (captured by a dummy variable equal to one in selected dates) as a measure of uncertainty (see also the early paper by Romer, 1990). Policy may be clearly another relevant source of macroeconomic uncertainty[5].

Baker et al. (2016) propose a broad policy uncertainty index based on the frequency of references to economic policy uncertainty in the news. More specific

[5]Policy uncertainty (i.e. not knowing which policy will be implemented) may be in turn due to political uncertainty (i.e. not knowing who will be in power). The economic effects of this latter variable have been studied, for example, by Julio and Yook (2012) and Canes-Wrone and Park (2014).

indicators are those related to trade policy and monetary policy, developed respectively by Handley (2014) and Creal and Wu (2016)[6].

The second stream of literature which our paper contributes to is concerned with the macroeconomic effects of discretionary fiscal policy. A review of that field is clearly outside the scope of this introduction, but it is well-known that there is no consensus about the size - and even the sign - of fiscal multipliers. On one side, studies like Blanchard and Perotti (2002) and Romer and Romer (2010) find standard demand-driven Keynesian effects; on the other side, starting from Giavazzi and Pagano (1990), other authors have argued that the effects of a fiscal policy change can be non-Keynesian, with the possibility of expansionary fiscal consolidations and contractionary fiscal expansions (a recent example is Alesina and Ardagna, 2013). Our main contribution to this debate is to show that fiscal policy-makers can influence the economy not only by changing the level of the budget deficit, but also by affecting its second moment. As a consequence, the same change in the government budget (say a budgetary expansion) can have different effects depending on whether it is associated with a reduction or an increase in the FPU.

From a policy perspective, our findings highlight the importance for policy-makers to contain uncertainty through a clear communication to the market. We then concentrate on a more recent period and we show that: 1) at the inception of the Trump administration, fiscal policy uncertainty increased substantially and has had a negative impact on both economic activity and employment; 2) our estimates encompass also the zero lower bound period when, if anything, the net effect of FPU shocks on economic activity should have been stronger due to the inability of the Federal Reserve to use interest rate to offset their adverse impact.

The remainder of the paper is organized as follows. Section 2 describes how we measure FPU: we outline our methodology, our data and estimates of the volatility; in Section 3 we present VAR estimates to show the effects of the fiscal shocks on macroeconomic variables. Section 4 concludes.

[6]A related stream of literature neglects the real effects of policy uncertainty, focusing instead on its financial consequences. See e.g. Kelly et al. (2016) and Brogaard and Detzel (2015). Other papers, e.g. Gulen and Ion (2015), look at the microeconomic (firm-level) effects of changes in policy uncertainty. Incidentally, both Brogaard and Detzel (2015) and Gulen and Ion (2015) use the Baker et al. (2016) index.

2 A forecast-based uncertainty measure

2.1 Forecast data

Our ultimate goal is to propose a sensible measure of *fiscal* uncertainty. Therefore, the first and obvious question relates to how we define fiscal uncertainty. Fernández-Villaverde et al. (2015) define it as the uncertainty surrounding the evolution of the average capital tax rate. However, it is apparent that the specific variable whose uncertainty they track is a narrow subset of the larger set of fiscal tools that a government can manage. We thus prefer to be as comprehensive as we can by focusing on uncertainty regarding the whole Federal Budget Balance. Moreover, what analysts usually look at is not the balance itself, but rather its relative size as compared to the whole economy. Therefore, we will track uncertainty regarding the deficit-GDP ratio.

As we already mentioned, Fernández-Villaverde et al. (2015) estimate fiscal uncertainty by applying a stochastic volatility model to the residuals of a fiscal rule. The estimated volatility process is their proxy for FPU. Although this is a sensible approach, it suffers from a potential problem, that is it focuses on what might be called *realized volatility* (where the reference to the financial econometrics counterpart is made on purpose). Realized volatility *on average* keeps track of the underlying latent volatility process, but in the short-term it can crucially miss important high-volatility episodes and therefore some FPU shocks.[7]

Therefore, when individual forecasts are available, those should be preferred as a basis for the computation of uncertainty measures, at least when we compare forecast dispersion with the above-mentioned model-based strategy. We do have access to individual expectations, and use Federal Budget Balance *monthly* forecasts from Consensus Economics (CE from now on). Recall that US federal government fiscal year starts on October 1^{st} and ends on September 30^{th}. As an example, fiscal year 2002 started on October 1^{st}, 2001, and ended on September 30^{th}, 2002. Therefore, fiscal year y starts in calendar year $y-1$ and ends on calendar year y. At each survey date in calendar year y (CE surveys are usually

[7]As a clarifying example, if X_t is a random variable with standard deviation σ_t and one draws *a single realization* from this distribution, there is no way one can even estimate σ_t with no further information. Of course one can estimate average volatility by estimating it using the whole sample at hand, but here we are explicitly focusing on time-varying volatility, i.e. one potentially different volatility estimate at each point in time. One then has to rely on some assumption on the law of motion for the latent volatility process to be able to recover the whole underlying series. Still, there might well be periods in the sample where the assumed DGP for volatility is not a good approximation, and in those cases the researcher would be inferring the volatility value with almost no guidance, that is, by combining one noisy data-point (as in the example above) with a wrong DGP.

held during the first week of the month) CE asks the individual forecasters to provide a forecast for fiscal year y *and* one for fiscal year $y+1$, *irrespective* of the month when the survey takes place. This means that fiscal year y forecasts provided during November and December calendar year y actually are *backcasts*, since fiscal year y ends on September 30^{th}[8].

2.2 Mixture distributions

Given the scheme of the survey, the first issue to be addressed concerns the fact that the forecast horizon varies each month. In particular, months that are closer to December tend to have a significantly lower forecast uncertainty. Therefore, we first need to find a suitable way to retrieve proxies for constant-horizon forecasts. We follow Brooks et al. (2004) simple weighting scheme and modify it in two fundamental ways. First (as we said) budget forecasts refer to the whole fiscal year period, which differs from the calendar year. Therefore, we assign weights as in Table 1. Note that November and December are assigned the same weight as October. The reason is that only respectively 11 and 10-months-ahead forecasts are available for those two months, meaning that the forecast horizon in those two cases is lower than 12 months.

Second (and most importantly) we argue that in order to retrieve a more reliable representation of the constant one-year horizon forecast distribution, one should use mixtures as opposed to taking a weighted average of the distributions. Weighting forecasts deterministically would be correct *only* if we would be interested in average forecasts. Indeed, two issues arise in our framework. First, weighted averages of distributions would surely misrepresent the dispersion of the resulting distribution, as it will become clear in the examples presented below. Second, deterministic weights would create strong seasonal patterns in the Federal Budget Balance forecast dispersion.[9]

We fix those issues by using probabilistic weights, i.e. by using a mixture distribution. Therefore, every 1-year-ahead forecast at month m is drawn from a distribution where with probability w (where w is defined as in Table 1) we pick the actual forecast for fiscal year t, and with probability $1-w$ we pick the one for fiscal year $t+1$. We simulate the underlying distribution by drawing from it a large number of times. The final product is a stochastically weighted average of forecasts, as opposed to the deterministically weighted usual one. Expected weights are the

[8]Note that fiscal year y forecasts provided during *October* calendar year y is a nowcast, since fiscal year y deficit datum is not yet available at the time of the survey, meaning that there exists some residual uncertainty regarding the actual value for the deficit.

[9]We provide an illustrative example in the Appendix.

Table 1: Weighting scheme, example

Calendar year 2002 Months	Fiscal year 2002 Weights w	Fiscal year 2003 Weights $1-w$
January	9/12	3/12
February	8/12	4/12
March	7/12	5/12
April	6/12	6/12
May	5/12	7/12
June	4/12	8/12
July	3/12	9/12
August	2/12	10/12
September	1/12	11/12
October	0/12	12/12
November	0/12	12/12
December	0/12	12/12

same as deterministic ones, and since the average is a linear operator, this yields the same average forecasts as those obtained with deterministic weights. Applying the combined test for the presence of seasonality on both the deterministic-weights and stochastic-weights series we find existence of identifiable seasonality in the former, but not in the latter.

Recall that we want to obtain a forecast distribution for the deficit-GDP ratio, and we want to do so by taking into account forecast uncertainty also in the nominal GDP forecasts. To this end, we use the Survey of Professional Forecasters to retrieve nominal GDP forecasts.[10] In order to show that the variation in the deficit dispersion dominates the one for GDP we proceed as follows. We first simulate the deficit-GDP forecast distribution, drawing individual forecasts for budget balance and GDP and take as our FPU proxy the standard deviation of their ratio. We then take the draws of the budget balance and divide all of them by the average of the draws of the GDP forecast to eliminate the effect of the dispersion stemming from GDP forecasts. At each time period does not make any visible difference in the shape of the final deficit-GDP forecast distribution and its standard deviation. Since we want to truly obtain a real-time series, we divide each month's deficit forecast by the latest GDP forecasts available at that time, and we can do so because survey dates are available for both series.

Finally, in the macroeconometric analysis that follows we use the residuals of

[10] Unfortunately CF does not provide nominal GDP forecasts.

the following regression as a measure of fiscal policy uncertainty shocks:

$$\log(\sigma_t) = \beta_0 + \sum_{k=1}^{p} \beta_k \log(\sigma_{t-1}) + \beta_{p+1} \left|\mathbb{E}_{t-1|t-2}(b)\right| + \eta_t, \tag{1}$$

where σ_t is the standard deviation of the deficit-GDP ratio forecasts, i.e. our measure of fiscal uncertainty; $\mathbb{E}_{t-1|t-2}(b)$ is the previous period *average* deficit-GDP forecast. The reason why we also control for past forecasts is that we believe it is more difficult to forecast the budget balance when the actual balance is far from being in equilibrium. Indeed, there exists a strong positive correlation between the standard deviation of the forecasts and the level of the forecasts, and the corresponding coefficient is significant and positive.

3 Fiscal Policy Uncertainty and the macroeconomy: a VAR approach

Having recovered the series of the fiscal uncertainty shock we are now ready to analyze its impact on macroeconomic variables. In particular, following Baker et al. (2016) we estimate a recursive autoregressive model, with monthly data from May 1993 to April 2018, where our measure of FPU is added as the first endogenous variable. We estimate the system:

$$Y_t = \alpha_0 + \delta_1 t + A(L)Y_{t-1} + \upsilon_t, \tag{2}$$

where the vector Y_t contains the variables: FPU shocks, log S&P500, Federal funds rate, log employment, log industrial production[11]. α_0 and δ_1 are vectors of coefficients, $A(L)$ is a polynomial matrix in the lag operator, t is a time trend, and υ_t a vector of white noise and mean-zero i.i.d. error terms.

Our system is estimated using standard Bayesian techniques. In particular, we use a non-informative prior (Jeffrey's prior) distribution on parameter space and an inverse Wishart distribution as the conjugate prior for the covariance matrix.

3.1 Baseline results

We compute impulse response functions to a one-standard-deviation shock in the fiscal policy uncertainty index.

Figure 1 shows the conditional movements of the US macro variables after

[11] Schwarz information criterion (SIC) selects 2 lags. We also add a linear trend component.

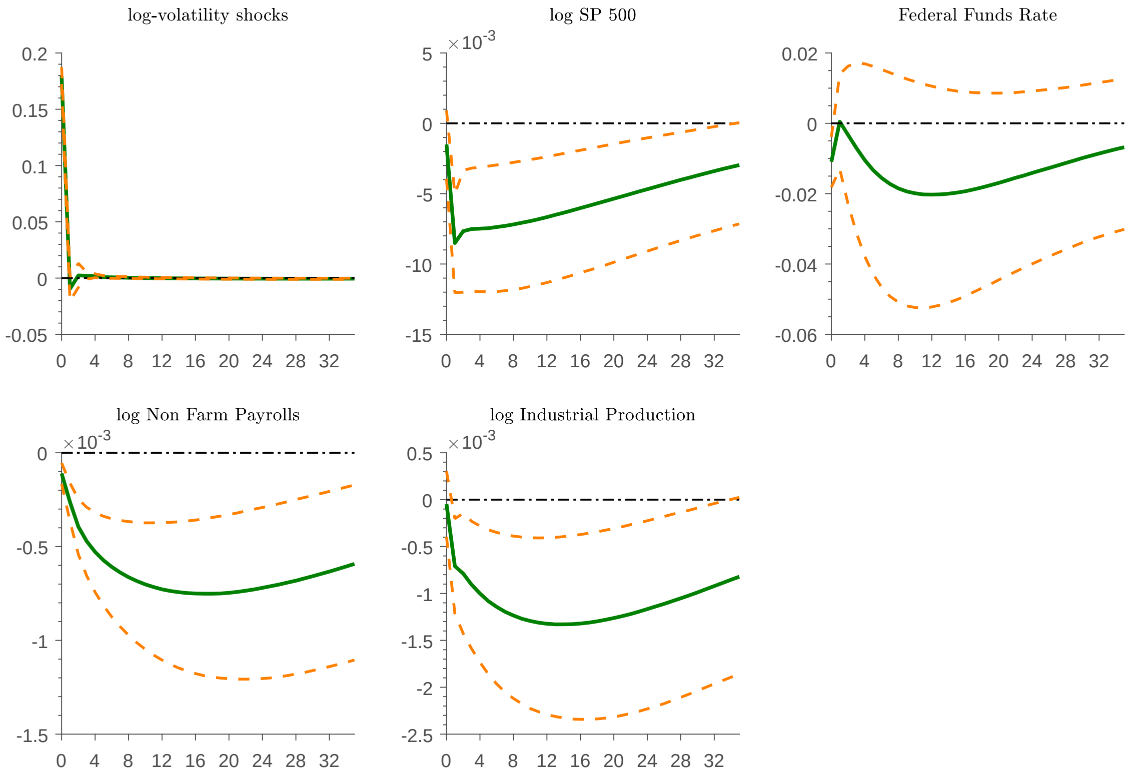

Figure 1: Impulse response functions, median and 68% confidence bands.

an unexpected increase in FPU. The industrial production persistently and significantly decreases reaching a negative trough of -0.13% after 10 months and employment persistently decreases reaching its negative trough (-0.08%) after 17 months. Our estimated effects are somewhat smaller then those recovered in previous studies: in the estimates by Baker et al. (2016) industrial production drops roughly by 0.36% and employment by 0.11%; in those by Fernández-Villaverde et al. (2015) quarterly GDP drops by roughly 0.2%. It is worth remembering, though, that the shocks considered in those two studies are not exactly the same ones recovered in our paper: the former is a broader policy uncertainty shock; the latter is a narrower shock to the capital income tax[12].

3.2 Uncertainty and the Trump Administration

We constructed several statistics to analyze the impact of the inception of the latest Administration on fiscal policy uncertainty, and all point in one direction: volatility increased after the election. In particular, our measure of fiscal policy

[12]Notice that the size of the shocks in Baker et al. (2016) and Fernández-Villaverde et al. (2015) was roughly three standard deviation in the first case and two standard deviation in the second. The comparison with our results already incorporates an appropriate rescaling.

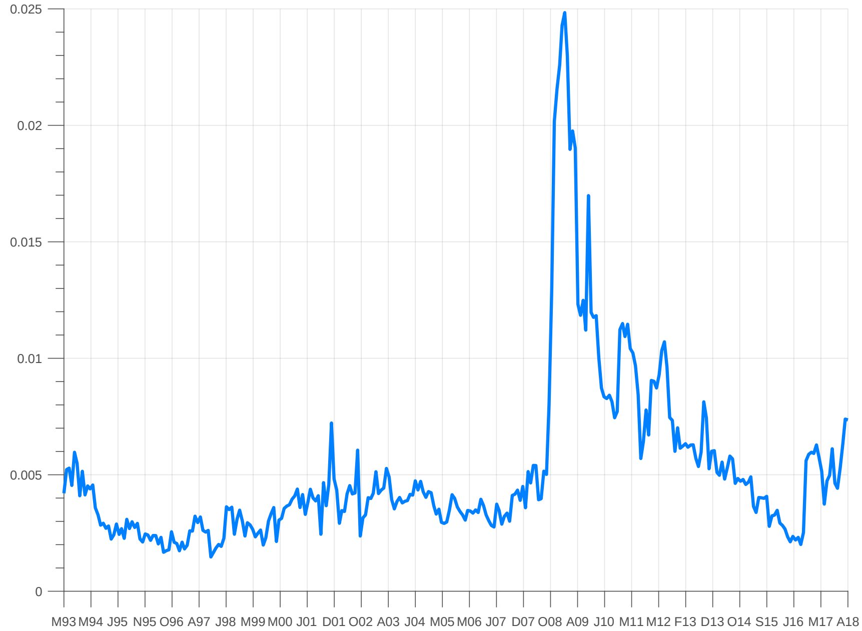

Figure 2: Standard deviation of the Consensus Economics budget balance forecasts.

uncertainty (forecast dispersion) increased: the forecast range widened, skewness changed sign and the historical decompositions reveals that uncertainty shocks started to put a brake on employment and industrial production recovery.

As shown in Table 2, between November 2016 and December 2016 dispersion increased by 0.4 percentage points. Figure 3 shows that the inter-90 range increased and skewness became negative right after the month of the Presidential election.[13]

Moreover, while in the year leading up to the Presidential election FPU shocks were contributing positively to both employment and industrial production, after November 2016 the cumulated contribution decreased to almost zero for both indicators. This can be seen from the two historical decompositions in Figures 4-5.

Summarizing, at the inception of the latest Administration: our measure of fiscal policy uncertainty increases from 0.3% to 0.7% (this is the 0.4 percentage points increase in the FPU reported in the first column of Table 2); one-year average inter-90 range goes from 1.16% to 2.52% and skewness drops from positive 0.3 to -0.6.

The historical decompositions show that benign fiscal volatility shocks were raising employment by almost 0.5% in November 2016. However, after the first year of Trump administration, the contribution halved. Similar results are observed

[13] Negative skewness can be easily inferred by the asymmetry in the 90% interval, i.e. the lower tail is much fatter than the upper tail.

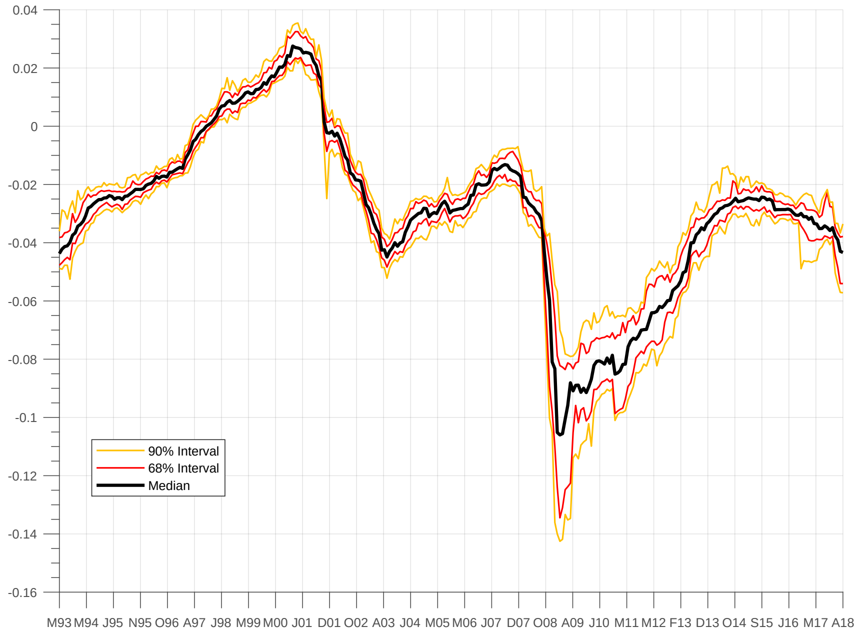

Figure 3: Median range of the CE forecasts together with 68% and 95% confidence bands.

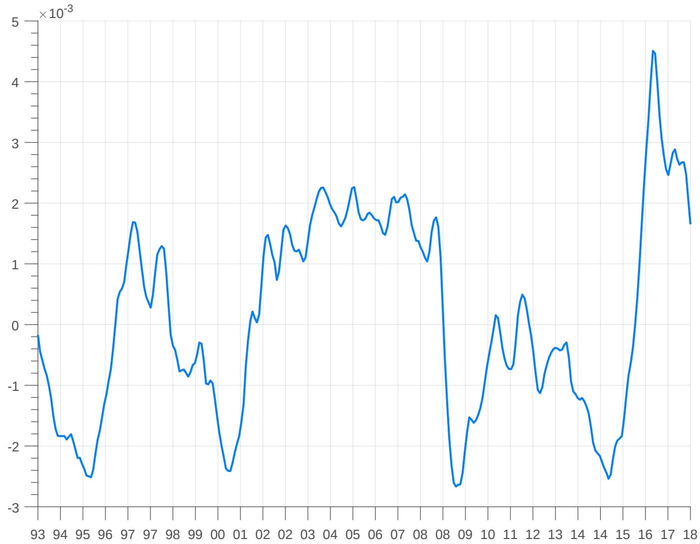

Figure 4: Historical decomposition of the employment rate: cumulated effect of FPU.

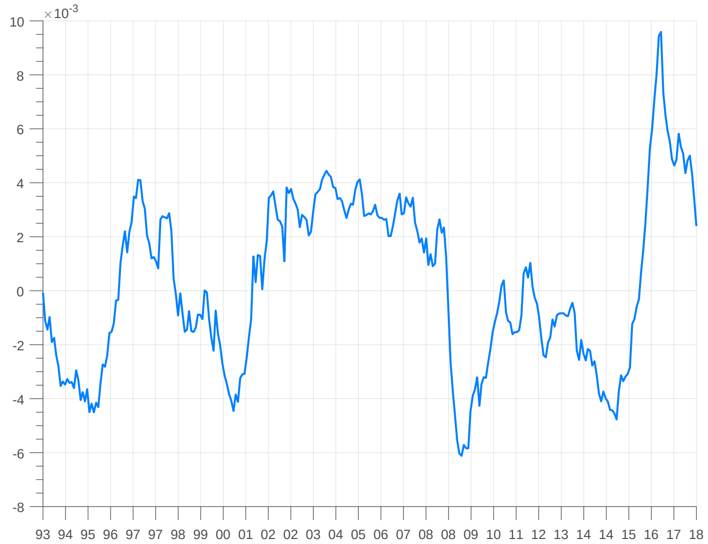

Figure 5: Historical decomposition of industrial production: cumulated effect of FPU.

for industrial production: the FPU contribution goes from positive 0.9% recovery to roughly 0.4%. Both measures continued to decline in the first four months of 2018.

Since it might be expected that fiscal policy uncertainty increases at the inception of a new Administration, Table 2 shows that the increase was actually larger than those experienced by all other Administrations covered in our sample, with the exception of the first Obama Administration, which took office in the middle of the global financial crisis. Also, the range of the CE forecast increased the most immediately after Trump victory, 1.4% and 0.7% for Range-90 and Range-68 respectively. Moreover, not only agents were more uncertain about the unfolding of fiscal policy, but they also expected future budget paths to be tilted toward leger deficits (skewness in the fourth column of Table 2 shows that an even larger expansion became more likely than a less expansionary path).

In Figure 6 we plot our FPU shock series (extracted from the VAR) together with the date of the first month after a presidential election[14]. It is easy to see that once expected components of FPU are taken into account, the Trump administration stands out also with respect to the first Obama administration. We therefore conclude that there is overwhelming evidence that the beginning of this new Administration generated a very large surge in fiscal policy uncertainty[15].

[14] In our sample, all presidential elections took place in November.

[15] Uncertainty decreased temporarily after the approval of the tax reform in late December 2017, but it then increased again and remained high till the end of our sample.

	FPU	Range-90	Range-68	Skewness
Clinton (1997-2001)	0.000	0.002	0.002	0.24
Bush (2001-2005)	0.001	0.006	0.002	-0.91
Bush (2005-2009)	-0.001	-0.003	-0.003	0.00
Obama (2009-2013)	0.018	0.055	0.037	-0.83
Obama (2013-2017)	-0.003	-0.012	-0.009	0.63
Trump (2017-Incumbent)	0.004	0.014	0.007	-0.59

Table 2: Statistics on fiscal policy uncertainty at the inception of the different US Administrations. All statistics are calculated as the difference in the annual averages one year after and one year before the US presidential election. FPU is the standard deviation of the budget balance Consensus Economics forecasts. Range-90 is the difference between the 95^{th} and the 5^{th} percentiles (negative numbers appears in the table because we report the difference in Range as explained above). The third column is the 68% band counterpart. Skewness is the third centered moment of the simulated empirical distribution of the CE forecasts.

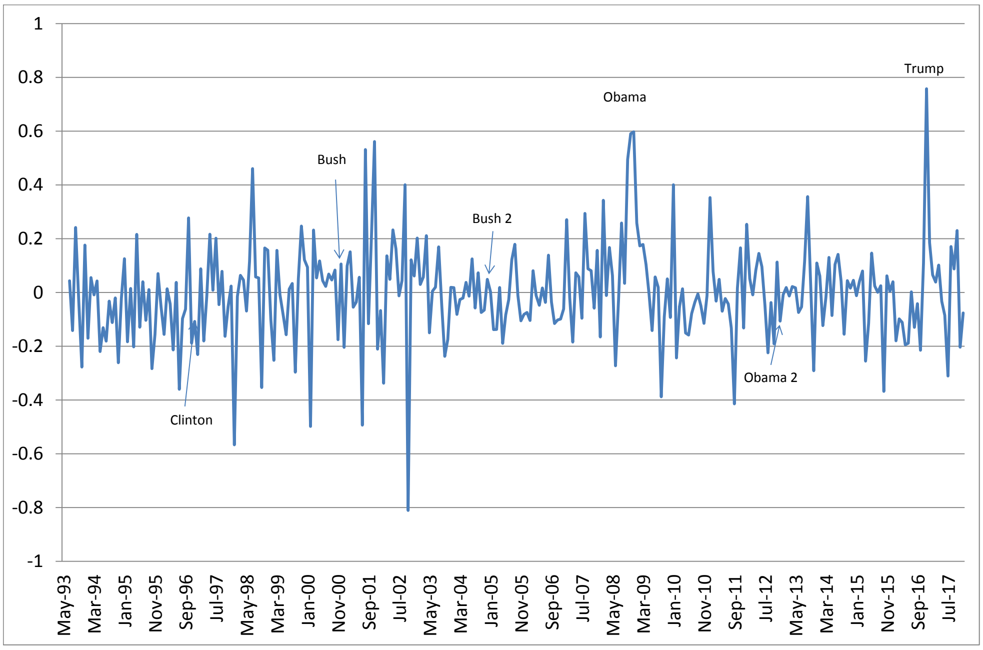

Figure 6: FPU shock series and presidential election date.

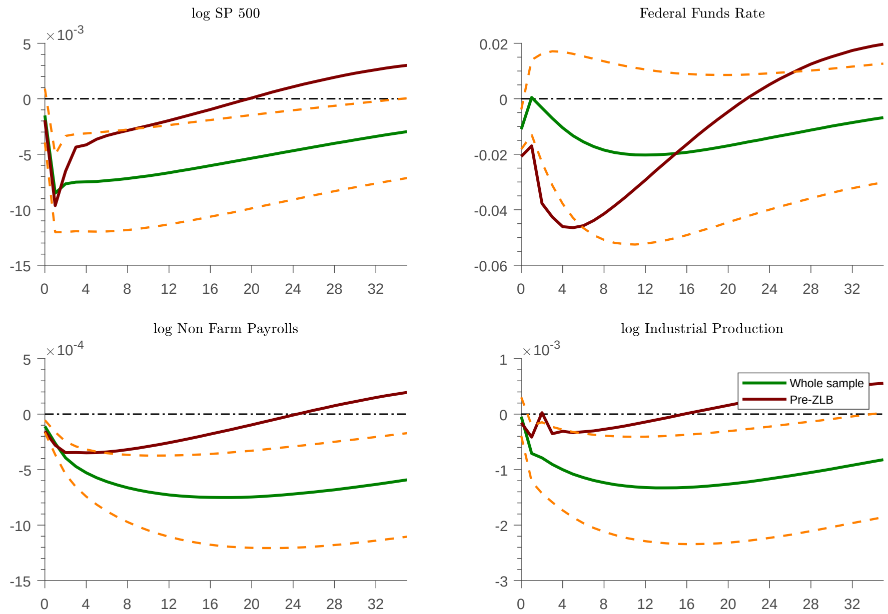

Figure 7: Impulse response functions with the whole sample and the median excluding the zero lower bound.

3.3 Uncertainty and the zero lower bound

In order to gauge the impact of the ZLB on the transmission of fiscal volatility shocks, we re-estimated the VAR and calculated the IRF both including and excluding from the sample the ZLB (May 1993 - December 2008 and May 1993 - December 2017). Figure 7 plots the median of the estimates obtained excluding the ZLB period together with our baseline IRF.

Apparently, excluding the zero lower bound period (a highly non-linear event) does not change our results. If anything, its inclusion amplifies the impact of fiscal policy uncertainty shocks because the Federal Reserve is unable to smooth them out by leaning against the wind[16].

4 Concluding remarks

In this paper we have developed a new forward-looking, real time and model-free measure of fiscal uncertainty. We exploit information on individual forecasts from two different surveys and propose a novel approach to deal with forecast horizon mismatches. In particular, we show that standard weighted averages of forecasts suffer from two unintended consequences. First, they generate strong seasonal patterns in the dispersion of the final distribution. Second, they miscompute the

[16] Fernández-Villaverde et al. (2015) reach the same conclusion.

variance of the target distribution. We simulate the constant one-year forecast horizon by combining consecutive years forecasts with mixture distributions, and we show that our approach solves both problems at once. The forward-looking nature of our metric defends it from the fiscal foresight critique[17].

We show that, much more than at the start of previous Presidential terms, the beginning of the Trump administration was characterized by a dramatic and persistent spike in fiscal uncertainty. While the overall impact of the fiscal policy of the new Administration is expected to be expansionary, we show that fiscal uncertainty shocks have negatively impacted economic activity, and that the initial wavering behavior of the new administration acted as a brake to the US recovery.

[17] See, for a clear explanation of the fiscal foresight, Leeper et al. (2013).

Appendix

We provide the intuition that clearly points towards using mixtures as opposed to weighted averages of distributions. Assume that:

$$X_1 \overset{iid}{\sim} \mathcal{N}(\mu_1, \sigma_1^2) \quad \text{and} \quad X_2 \overset{iid}{\sim} \mathcal{N}(\mu_2, \sigma_2^2),$$

and that we are interested in mixing the two variables in order to obtain a final random variable Z that contains some information from the two distributions. In particular, we want to apply some weighting scheme, where w and $1-w$ are weights for X_1 and X_2 respectively. If we take a simple weighted average of the two distributions, we obtain that Z is still normally distributed, with

$$\mathbb{E}(Z) \equiv \mu = w\mu_1 + (1-w)\mu_2,$$

and

$$\mathbb{V}(Z) = w^2\sigma_1^2 + (1-w)^2\sigma_2^2.$$

On the other hand, if we adopt a mixture distribution, we analytically obtain exactly the same expected value for Z as in the weighted average case, whereas we obtain a different value for the variance, particularly

$$\mathbb{V}(Z) = w((\mu_1-\mu)^2 + \sigma_1^2) + (1-w)((\mu_2-\mu)^2 + \sigma_2^2).$$

It is easy to see that the weighted average scheme wipes out a great part of the variance from both distributions, whereas the mixture entirely and properly preserves the supports from both distributions, which is what we need in our setting. A numerical example can help in clarifying matters. Assume that $\mu_1 = \mu_2 = 0$, $\sigma_1^2 = 1$, $\sigma_2^2 = 2$, and $w = 0.5$. One can easily check that $\mathbb{E}(Z) = 0$ in both cases, but $\mathbb{V}(Z) = 0.75$ in the weighted average scheme, and $\mathbb{V}(Z) = 1.5$ with the mixture. Therefore, the weighted average yields (and this of course is a well known result) a final variable whose variance is *half* the average of the two original variances, whereas the mixture yields a variance that is *exactly* the weighted average of the two original variances. Furthermore, note that in the weighted average case the variance of Z is an additive linear function of w^2 and $(1-w)^2$. Since $w \in [0,1]$ and since w changes *periodically* (with a yearly frequency) over time, it is apparent that the U-shaped pattern induced by the function $w^2 + (1-w)^2$ will create a strong (and surely undesired) seasonal component in $\mathbb{V}(Z)$, and this problem is indeed confirmed when the weighted average scheme is applied to our dataset.

The above is, of course, a thought experiment, and things would be different for different parameters choices and if one were to assume away normality and independence between the two random variables. Crucially, however, the underlying intuition remains valid.

It is therefore clear that using the mixture distribution is the best approach in our case, where we are interested in the whole shape of the forecast distribution. Indeed, when weighting forecasts for two different and consecutive fiscal years, we would like the resulting random variable to have a support that represents in a proper way the underlying uncertainties, and not one that collapses the two supports in an average one, losing crucial information. As a further clarifying example, imagine to have $\mu_1 = 1$, $\mu_2 = -1$, $\sigma_1^2 = \sigma_2^2 = 1$, and $w = 0.5$. In this case, we would still obviously have a zero expected value in both cases, but in the weighted average case we would have $\mathbb{V}(Z) = 0.5$, whereas in the mixture distribution case we would have $\mathbb{V}(Z) = 2$. In the first case the resulting Z has a support that heavily misrepresents the two original supports, and further reduces the variance to a very low level. In general, the weighted average would yield the same result if it was mixing two identical zero-mean distributions or if it was mixing two distributions with same variance but where $\mu_1 = -\mu_2$. This is clearly undesirable. Instead, the mixture again correctly adjusts and properly merges the two original densities.

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