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Joining the Dots: The FOMC and the future path of policy rates

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Non Technical Summary

Given the importance of US monetary policy for global economic and financial conditions, economic policy makers and market analysts across the world devote great resources to understand the Federal Open Market Committees (FOMCs) outlook for monetary policy. To help them in this process, the Federal Reserve has since 2012 published on a quarterly basis FOMC members' assessments of *"appropriate monetary policy"*. This is defined as *" the future path of policy that each participant deems most likely to foster outcomes for economic activity and inflation that best satisfy his or her interpretation of the Federal Reserves dual objectives of maximum employment and stable prices"*. The dot plots of members assessments are now eagerly anticipated and much analysed by market participants.

It is natural to ask how FOMC members' views of the appropriate level of interest rates have evolved over time and how they have responded to changes in the macroeconomic environment. In particular, how sensitive have they been to changes in labour market conditions, indicators of economic activity and inflation pressures? Addressing this question is complicated by the fact that Federal Reserve typically only publishes these views for four or five discrete points in time. Changes between FOMC meetings in the projected path of interest rates thus reflect both shifting economic conditions and changes in the forecast horizon. They can therefore not be used directly to answer the question of what factors drive FOMC members' assessment of the appropriate level of interest rates at a constant horizon, such as one or two years ahead.

In this paper we ask how FOMC members views of the future path of appropriate monetary evolved over time and how they responded to changes in the macroeconomic environment. To do so, we first quantify the amount of variation in FOMC members views of appropriate monetary policy. We then estimate a simple empirical model which allows us to interpolate the path of interest rates the FOMC members, on average, believe is appropriate to achieve their policy objectives. We compute the average view of the appropriate interest rate at constant maturities of one, two and three years, and end by studying how these views respond to current macroeconomic conditions.

As one of the first studies of the FOMC's interest rate projections that we are aware of, this paper is interesting for a number of reasons. First, we quantify the dispersion of FOMC members' views of interest rates which is critical for judging the outlook for US monetary policy. It is interesting to consider how dispersion varies with the horizon of the projection and over time, given the broader economic uncertainty during the sample period. Second, we show that a simple model can be used to interpolate the interest projections between the discrete data points published by the Federal Reserve. Finally, we show that FOMC members' projections have been more sensitive to labour market conditions than to inflation rates in our sample period.

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Abstract

The Federal Reserve publishes since 2012 Federal Open Market Committee (FOMC) members' views regarding what federal funds rate will be necessary for the FOMC to achieve its statutory targets. The views or "projections" pertain to the end of the current and the next two or three years, and the "longer run." We use a simple model to interpolate the projections between these discrete points in time, estimate the interest rates one, two and three years ahead, and study how they evolve with macroeconomic conditions. News regarding the labour market, but not inflation, affects the projections in the sample period.

Keywords: Federal Reserve, monetary policy, interest rate expectations, interpolation.

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1. Introduction

Given the importance of US monetary policy for global economic and financial conditions, economic policy makers and market analysts across the world devote great resources to understand the Federal Open Market Committee's (FOMC's) outlook for monetary policy. To help them in this process, the Federal Reserve has since 2012 published on a quarterly basis FOMC members' assessments of "appropriate monetary policy." This is defined as "… *the future path of policy that each participant deems most likely to foster outcomes for economic activity and inflation that best satisfy his or her interpretation of the Federal Reserve's dual objectives of maximum employment and stable prices"*.[1] The 'dot plots' of members' assessments are now eagerly anticipated and much analysed by market participants.

Figure 1 shows the 'dot plot' for September 2015, the meeting immediately before the FOMC raised rates in December 2015.[2] Each dot represents one FOMC member's projection of interest rates for each of 2015, 2016, 2017, 2018 and "the longer run", which the Federal Reserve implicitly defines as the level that interest rates would converge to over time in the absence of further shocks.[3] In September 2015, FOMC members' projected interest rates for the end of 2015 to be around 0.5%. The federal funds rate is projected to increase over the following three years and, in the longer run, members' project it so settle at approximately 3.5%.

The dispersion of the dots indicates the degree of consensus among members on interest rates. While in the short run the range of forecasts is more than 1 percentage point, in the medium term the range is even greater and is sometimes in excess of 2 percentage points. Members are more confident about the longer run: the range falls to 1 percentage point. Overall, the degree of dispersion seems very large; FOMC

[1] See www.federalreserve.gov/monetarypolicy/files/fomcprojtabl20160316.pdf
[2] More information about how the FOMC constructs this plot is available in Section 3.1.
[3] The Federal Reserve suggests that this is 'maybe in five to six years'.

members are evidently highly uncertain about what future path of interest rates will be appropriate.

It is natural to ask how FOMC members' views of the appropriate level of interest rates have evolved over time and how they have responded to changes in the macroeconomic environment. In particular, how sensitive have they been to changes in labour market conditions, indicators of economic activity and inflation pressures? Addressing this question is complicated by the fact that Federal Reserve publishes the views of individual members and not for the overall FOMC. Furthermore, as can be seen from Figure 1, it typically only publishes these views for four or five discrete points in time. Changes between FOMC meetings in the projected path of interest rates thus reflect both shifting economic conditions and changes in the forecast horizon. They can therefore not be used directly to answer the question of what factors drive FOMC members' assessment of the appropriate level of interest rates at a constant horizon, such as one or two years ahead.

In this paper we present some preliminary answers to this question. In doing so, we first characterize the differences between FOMC members' views of appropriate monetary policy. We go on to estimate a simple empirical model, in lieu of a proper term-structure model, which allows us to interpolate the projected path of interest rates that FOMC members, on average, believe will be appropriate, given macroeconomic conditions. Using the estimated models, below we compute the projected future interest rate at constant horizons of one, two and three years and study how they respond to changes in current macroeconomic conditions.

As one of the first studies of the FOMC's interest rate projections that we are aware of, this paper is interesting for a number of reasons. First, we quantify the dispersion of FOMC members' views of interest rates which is critical for judging the outlook for US monetary policy. It is interesting to consider how dispersion varies with the horizon of the projection and over time, given the broader economic uncertainty during the sample period. Second, we show that a simple model can be used to interpolate the interest projections between the discrete data points published by the Federal Reserve. Finally, we show that FOMC members' projections have been more sensitive to labour market conditions than to inflation rates in our sample period.

The paper is organized as follows. In the next section we discuss the related literature. Section 3 describes the data, including the sample size, frequency and dispersion of FOMC members' projections. In Section 4 we present the empirical model which we use to interpolate between the discrete data points to obtain a curve for the projected path of the federal funds rate, averaged across FOMC members. In Section 5 we construct projected interest rate at constant horizons of one-, two- and three-year ahead, and study how they evolve in response to incoming macroeconomic data. We also include a number of robustness checks. Section 6 concludes.

2. Related literature

Although a long literature exists on central bank transparency and communications[4], this is one of the first studies of FOMC members' projections. Previous studies have used these data in conjunction with the macroeconomic projections for inflation, unemployment and real GDP that are also made by FOMC members. For instance, Feroli et al. (2016) use these projections to estimate empirical reactions functions of the Taylor variety and find that changes in the interest rate projections can be inferred from changes in the outlook for macroeconomic variables. Kahn and Palmer (2016) carry out a similar exercise and find that, although the FOMC member's interest rate projections were consistently wrong over the sample period, they reflected a systematic planned response to forecasts of macroeconomic variables which was similar to actual responses to inflation and unemployment changes in the pre-crisis period. Berriel et al. (2015) use the interest rate projections in a dynamic stochastic general equilibrium framework, arguing that the degree of path dependence of the

[4] See, for example, Blinder et al. (2008), Dincer and Eichengreen (2009), Issing (2005) and Geraats (2009).

interest rate implied by the projections declined in 2014-2015, suggesting that the FOMC was pursuing a more discretionary monetary policy during this period.

There is also a literature studying the publication of central bank's forecasts of interest rates. A small number of central banks, including Norges Bank and the Reserve Bank of New Zealand, produce a single forecast of the policy rate path, as opposed to the individual forecasts of the FOMC. Winkelmann (2010) shows that the publication of projections by the Norges Bank has reduced financial market participants' revisions of the expected future policy path. Moessner and Nelson (2008) find that the RBNZ's interest rate projections have a statistically significant impact on future rates on the announcement day. However, others suggest that interest rate projections may not provide additional information to market participants. Goodhart and Wen (2011) show that the RBNZ's rate projections are inefficient for horizons greater than two quarters. Mirkov and Natvik (2013) find that policymakers may be constrained in their interest rate decision by their most recently published forecasts.

3. Data description

3.1 The data

In this section we describe the data. Since January 2012, each member of the FOMC provides end-year projections for the federal funds rate for the coming years and the long-run.[5] Members make these projections in preparation for the FOMC meetings, although they are not released to the public until immediately afterward. In 2012, projections were made in advance of the January, April, June, September and December FOMC meetings. Thereafter, projections were made in advance of the March, June, September and December meetings. In March and June, members

[5] Members also provide projections for macroeconomic variables at the same time. These macroeconomic projections were published after the meetings prior to January 2012, however, it was not until January 2012 that interest rate projections were included.

provide projections for four forecast horizons: the end of the current year, the ends of the following two years, and the "longer run". In September and December, projections for five horizons are made: the end of the current year, the ends of the following three years and the "longer run".

A presentational change in the data occurred in September 2014. Up until this point, all forecasts were rounded to the nearest quarter of a per cent, with the exception that all values below 0.375 percentage points were rounded to 0.25%. As such, the individual projections take values of 0.25%, 0.5%, and so on, rising in steps of 25 basis points. From September 2014 onwards, the projections have been rounded to the nearest one eighth of a per cent, and show the member's judgement of the midpoint for the appropriate target range or level of the federal funds rate. This results in projections taking values of 0%, 0.125% and so on, rising in values of 12.5 basis points. In addition, the latter methodology allows for negative projections to be published, which is the case with one member's current-year projection in September 2015.

Furthermore, the number of projections for each meeting is not uniform, since the number of FOMC members varied throughout the sample period studied. In January and April 2012, there were 17 members but for the following 5 meetings there were 19 members. From September 2013 to June 2016, there were 17 members, with the exception of March and June 2014, when there were just 16 members. In addition, at the June 2016 meeting, St Louis Federal Reserve President James Bullard did not provide a projection for the longer run interest rate. The number of projections following each meeting varies accordingly.

3.2 The level and dispersion of views

Figure 2 shows the evolution of the median projection at each horizon over the sample period that spans the period from January 2012 to June 2016.[6] For instance, the projection for the end of the "current year" remains at 0.25%, its lowest possible level,

[6] We use the median projection as this is the preferred measure used by the Federal Reserve in presenting the projections of activity and inflation which the FOMC members also make.

for the entire period up to June 2014. As noted above, after June 2014 projections below 0.375% were no longer rounded to 0.25%. As a result, the interest rate projection declines to 0.125% in September and December 2014. From the beginning of 2015, FOMC members' projections for the "current year" begin to signal "lift-off" in interest rates.

Interestingly, the median projection for "next year" also stays at 25 basis points from the beginning of the sample period, but begins to rise in March 2014, suggesting that members expected rates to rise in 2015. Similarly, in March 2013 FOMC members projected interest rates to start rising in two years' time. This indicates that, from early 2013, FOMC members consistently projected a rate increase sometime in 2015, which indeed occurred in December of that year.

In contrast, the projections for "longer run" rates decline during the sample period. FOMC members projected these rates to be slightly above 4% at the start of the sample period. However, the decline in the "longer run" projections is evident throughout the sample period, and is particularly marked in March and June 2016, when the projection falls to just 3%.

Figure 3 shows the range of projections at each horizon at each point in time.[7] The Figure shows that the range is generally lowest for the end of current year projection, and increases progressively as the horizon lengthens, with the exception of the "longer run" projection. This is an unsurprising result. First, shorter horizons are easier to forecast than longer horizons. Furthermore, since interest rates were close to the zero lower bound throughout much of this period, the projections tended to cluster close to zero at shorter horizons. Projections made for intermediate forecast horizons require more judgement about the future path of the economy, the size and likelihood of shocks, and their impact. In contrast, the "longer run" projection can be regarded as

[7] The patterns are broadly the same if the standard deviation of projections, rather than the range, is used as a measure of dispersion.

the interest rate that would prevail once the economy reaches its steady state. As such, it seems natural that FOMC members' projections for this horizon would be similar.

The evolution of the range is also evident from Figure 3. First, it is notable that there are a number of points towards the end of the year at which there is no disparity in views for the current year. Second, while the range for the current year projection remains steady over the sample period, the range for the next year and two year ahead projection increases rapidly in early 2014 and only begins to return to earlier levels at the end of 2015. This indicates increasing uncertainty among FOMC members about the outlook during this time. Finally, the range of projections for the longer run remains relatively stable up to early 2015 but then begins to decline significantly. Overall, it is clear that FOMC members are highly uncertain about the outlook for monetary policy.

4 Interpolating the interest rate projections

4.1 Method

Next we turn to the problem of computing constant horizon projections of the interest rate. The dots, typically, pertain to the end of the current and next two or three years and in the "longer run." Changes in the projected interest rate from one quarter to the next thus reflect two factors. The first is the new information that has been received during the quarter, and the second is the fact that the forecast period has been shortened (e.g., "the end of next year" is now one quarter closer in time). In order to compute interest rate projections for constant horizons we must distinguish between these two effects.

Here we do so by interpolating the projected interest rate between the data points. Each FOMC members' projections of the future federal funds rate can be interpreted as four or five data points on the instantaneous forward curve. We could in principle proceed by fitting a term structure model of the Nelson-Siegal, or the Nelson-Siegal-Svensson, variety on these data.[8]

However, even though we have more than 60 projections of the future interest rate per quarter, they pertain to only four or five maturities. This makes it difficult to fit a term structure model. Furthermore, we face the difficulty of fitting yield curves at the zero lower bound, as the federal funds rate was essentially zero through most of our sample period.[9]

Instead, we merely seek to approximate the shape of the term structure using a smooth functional form to enable us to interpolate between the observed data points. Empirically, it turns out that a simple logit function captures the maturity structure of the FOMC's interest projections very well.

Thus, we consider models of the form:

$$(1) \qquad P_{i,t}r_m = \delta_0 + \frac{exp(\sigma(m-m_0))}{1+exp(\sigma(m-m_0))}\delta_1 + \varepsilon_{i,m,t}$$

Where $P_{i,t}r_m$ denotes the projection, P, of the *i:th* FOMC member at time *t* of the interest rate r at maturity m.

To interpret this equation, consider a short maturity such that the term involving the ratio of the exponentials is approximately zero ($m \ll m_0$). Thus, δ_0 captures the level of the interest rate projection for short maturities.

Next consider a long maturity such that the term involving the ratio of the exponentials is approximately unity ($m \gg m_0$). Thus, $\delta_0 + \delta_1$ can be thought of capturing the expected longer run level of interest rates.

Next, suppose $m = m_0$ in which case the term involving the ratio of the exponentials equals 0.5. We can therefore think of m_0 as the maturity at which half of the transition from the current to the longer run level of interest rates is achieved.

[8] See Nelson and Siegel (1987) and Svensson (1994).

[9] See the discussion in Bauer and Rudebusch (2013).

Finally, note that σ captures how quickly the interest rate rises toward the fixed level as the maturity increases.

In estimating the model, we take account of the fact that the March, June, September and December FOMC meetings are scheduled in the middle of the month, by including the second half of the month as part of the projection horizon.[10] As such, the March projection for the end of the current year is set at 9.5 months ahead, the next year projection is 21.5 months ahead, and so on.[11]

Furthermore, we can make use of an initial condition given by the fact that FOMC members know recent effective federal funds rates when they make their projections. To see how to do so, consider estimating the model at time t. We have the data points from the members' projected future ($m > 0$) federal funds rates. We can apply the restriction that the curve passes through the effective Federal Funds Rate at the end of the month preceding the meeting, that is, roughly 0.5 months earlier.

In terms of the model estimated for time t, we can think of that as requiring that for the *negative* maturity $m = -0.5$, the curve must equal the realised effective federal funds rate, $r^{ef}_{t,m=-0.5}$.[12] We use the effective Federal Funds Rate since policy is expressed as a band in our sample period.

This allows us to solve for δ_1, and re-write equation (1) as:

$$(2) \qquad P_{i,t}r_m = \frac{exp(\sigma(m-m_0))}{1+exp(\sigma(m-m_0))} \times \frac{exp\left(-\sigma(\frac{1}{2}+m_o\right)}{1+exp\left(-\sigma(\frac{1}{2}+m_o\right)} \cdot r^{ef}_{t,m=-0.5} + \varepsilon_{i,m,t}$$

where we have made use of the fact that δ_0 is unidentified so we can constrain it to zero.

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[10] For instance, 2016 meetings were scheduled on 15-16 March, 14-15 June, 20-21 September and 13-14 December.

[11] Special consideration is needed for January and April 2012. Since these meetings took place at the end of the month, the end year projection for 2012 made in January, is 11 months ahead, and so on.

[12] Or $r^{f}_{t,m=-1}$ in the case of January and April 2012, as these meetings took place at the end of the month. The federal funds rate data are taken from the Federal Reserve Bank of New York's website: apps.newyorkfed.org/markets/autorates/fed%20funds.

The non-linear curve described by equation (2) involves solely two unknowns, m_o and σ. Remarkably, as we show below, it nevertheless does a good job of capturing the term structure of interest rate projections.

Below we fit the equation using non-linear least squares for each quarter for which interest rate projections have been published and use the predicted value for 12, 24 and 36 months ahead in the subsequent econometric analysis.

4.2 Estimates

In Table 1 we show the estimates of m_o and σ, their standard errors and the r-squared from the regressions for each quarter. In fitting the model we need to take a stand on what is meant by the "longer run." One natural interpretation is that it denotes the level at which the expected federal funds rate is constant, that is, when $\frac{\partial P_{i,t} r_m}{\partial m} = 0$. Of course, the logit function asymptotes to a constant for long maturities and this is one reason why it is attractive for interpolating the yields. The estimates below are based on the "longer run" corresponding to 7 years (or 84 months).

Recall that m_0, which is measured in months, is the horizon at which half of the transition from the current to the longer run level of interest rates is achieved. The estimates of m_0 therefore indicate how soon FOMC members believe interest rates will rise. The estimates of m_0 in Table 1 indicate that FOMC members envisaged that interest rates would be slow to rise towards their longer run level throughout 2012. For instance, in January 2012 the half-way point was about 45 months ahead. Indeed, the estimate of m_0 is largest in December 2012, when FOMC members' projections indicated that interest rates would not have increased to half their long run level within 4 years ($m_0 = 49$). Thereafter, members began to anticipate rates rising sooner and/or faster, and the estimate of m_0 generally declines throughout the remaining meetings. By June 2016, the estimates indicate that members believed that interest rates would have reached half their long-run level in about 1.5 years ($m_0 = 18$).

In contrast to m_0, σ captures how quickly the interest rate rises toward the longer run level, once lift-off has taken place. As discussed by Mankiw, Miron and Weil (1987), the "transition time" between when one quarter and three quarters of the adjustment towards the longer run level has occurred is given by $\ln(9)/\sigma$.

The estimates of σ indicate that FOMC members were gradually reducing their expectations of the speed at which interest rates would increase over 2012. Thus, in January 2012 the estimate of σ is 0.089, corresponding to a transition time of 25 months. By December that year, the transition time is 33 months. However, from then onwards, members generally expected the transition to be faster. For instance, in December 2014 the transition time is 12 months. In June 2016 the transition time was a little longer at 18 months.

As can be seen from the final column of Table 1, the r-squared for these regressions is in the range of 0.74 to 0.91. The goodness of fit is explored further in Figure 4 which shows the fitted curve for September 2015, corresponding to the 'dot plot' in Figure 1. This is also the meeting immediately before the FOMC raised interest rates. For each of the four maturities for which projections were made, we also indicate the median projections together with a 95% confidence band. Importantly, the fitted curve is very close to the median value: the curve is 14 basis points away from the median FOMC projection at the end of the current year (in this case 2015) and 15 basis points away from the median FOMC projection at the end of 2016. This deviation can be compared to the standard deviations of the interest rate projections at these horizons, which are 25 and 69 basis points, respectively.

For the end of 2017, 2018 and in the longer run, the difference between the fitted values and the average projections are 16, 3 and 6 basis points, respectively. By comparison, the standard deviations of the projections are 75, 32 and 26 basis points, respectively. These findings, which are similar to those obtained at other points in time, suggest that the differences between the fitted value and the median projections are small.

4.3 Fitted curves

Figure 5 shows the final fitted curves for all projection rounds. Month 0 can be considered the date when the projections are made. The curve shows the interpolated projections over the following 84 months (or 7 years). By the end of this period we assume that we are in the "longer run". Nonetheless, some of the curves, particularly at the start of the sample, have not fully asymptoted to a horizontal line at this point. This suggests that our functional form is a little restrictive.

The changes over time in the expected timing and speed of interest rate increases are noticeable. In the first part of the sample, the curves indicate that interest rates will not increase significantly for a number of months, and the increases will be gradual once they do begin. By mid-2014, an interest rate increase was expected much sooner, and interest rates were expected to increase rapidly once this occurred. By June 2016, interest rate increases were expected almost immediately.

Changes in the levels of interest rates are also evident. Expected interest rates are low at the short-end throughout the sample period until immediately after the interest rate increase in December 2015. Similarly, the decline in the long-run interest rate projection is evident, particularly at the end of the sample.

5. Estimates of the impact of macroeconomic news on the projections

5.1 Results

Next we explore the information content of the FOMC's interest rate projections. To do so, we computed the fitted value of the projection at time t, of the interest rate at maturity m, $\widehat{P_t r_m}$, for the constant maturities of one, two and three years, referred to as m = 12, 24 and 36. (We drop the i subscript because the fitted value is the same for all FOMC members.)

As a preliminary, in Figure 6 we plot the fitted value of the interpolated constant maturity interest rate forecasts against the closest actually observed forecast for m = 24 (the plots for m = 12, 36 look similar and are omitted in the interest of brevity). While the two series evolve in similar ways, the interpolated constant maturity forecast is much smoother. This is of course as one would expect since the maturity of the closest FOMC projections varies from 19 months to 28 months.

To explore how the projections move with macroeconomic conditions, we next estimate models of the form:

(2) $$\widehat{P_t r_m} = \alpha_k + \alpha_{k,j} x_{k,t-j} + \varepsilon_t$$

where $x_{k,t-j}$ denotes the *j:th* lag of *k* measures of macroeconomic conditions at the time the FOMC members assess the appropriate path of interest rates.

Before proceeding, two econometric points are in order. First, $\widehat{P_t r_m}$ is estimated and can be thought of as subject to some measurement error. Since it is the dependent variable, this will merely increase the variance of the regression residuals, thus leading to an underestimate of the significance of the regression parameters. Second, the regression errors are likely to be serially correlated, so we use Newey-West standard errors.

The *k* variables we study here include PCE inflation, PCE inflation excluding food and energy (PCE core inflation), growth in nonfarm payrolls and the unemployment rate, since much market commentary focus on these variables. The lag length *j* is typically one or two months.

It is important that only macroeconomic information that is known to FOMC members when they make their projections is used in the regressions. The March, June, September and December meetings take place in the middle of the month. FOMC members make their initial projections by the end of the Friday before the FOMC meeting, but can revise them any time before the beginning of the second day's meeting.[13] As all our macroeconomic variables are available on a monthly frequency, members will not know PCE and PCE core inflation for the previous month, since these data are published with a lag of at least four weeks. In contrast, nonfarm payrolls

[13] See: https://www.federalreserve.gov/monetarypolicy/fomc_projectionsfaqs.htm

and the unemployment rate are both available within a week of month-end, and would be available to FOMC members when they make their projections.[14]

Since we have just 19 observations, it is possible that if we include too many explanatory variables none will be significant. We first estimate equation (2) for m = 12, 24 and 36 using a single regressor. Estimates are presented in the upper panel of Table 2. Three findings are of interest. First, the coefficients on the inflation measures are significant but negative, implying that, as inflation increases, the projected interest rate falls. This suggests omitted variables bias. Second, while the unemployment rate and the growth in non-farm payrolls are both significant, the r-squared is much higher for the unemployment rate. Third, the r-squareds are broadly similar for the three horizon, although perhaps a little lower for m = 12.

We next include all variables in a multivariate version of equation (2), and drop insignificant variables from the regression sequentially. As can be seen from the lower panel of Table 2, for m = 12 core inflation and the unemployment rate are significant determinants of the fitted interest rate projection. The sign on the inflation rate is now positive as one would have expected: as inflation rises, so too does the expected future interest rate.

At m = 24 and 36, inflation is not significant (although when it is included, its parameter is positive) but non-farm payrolls and the unemployment rate are both significant. However, the increase in the r-squared relative to the regressions when unemployment is used alone is small.

Overall, these results suggest that, since 2012, FOMC members' projections of the interest rate responded more strongly to labour market conditions than to inflation. During this sample, inflation generally declined, and was below the FOMC's stated target of 2 per cent. Since inflation was under control, it is not surprising that the

[14] Special consideration is required for 2012, when projections were made at the January and April meetings. However, since these meetings took place on the 24-25 in both months, the PCE and core PCE inflation data would still not have been available to members.

FOMC was responding more strongly to labour market conditions which were weak but started to improve sharply.

5.2 Robustness checks

We next perform robustness checks. First, we consider variations in the lag with which information is available to FOMC members. In the analysis above we assumed that FOMC members only gain information when the official statistical release is published. As a result, we included the first lag of the growth in non-farm payroll and the unemployment rate, and the second lag of the inflation measures. However, it is possible that members have some understanding of recent trends in inflation through anecdotal evidence, forecasts or other sources. As such, it is of interest to re-estimate the model with all explanatory variables lagged by just one month. We therefore first assume that members may have some sense of the previous month's inflation rate, for instance because oil prices changes – which are important drivers or headline inflation – are observed, even though it is unavailable when they make their projections.

Since the univariate regressions performed poorly earlier, we focus on multivariate regressions, which are available in Table 3. For m = 12 inflation and core inflation are significant as is the unemployment rate. However, inflation enters with a negative sign. As in the case of the baseline model, for m = 24 and 36 only the labour market variables are significant. The similarity of the r-squareds with those in Table 3 shows that the changes in the conditioning variables have a trivial impact on the results.

Next, we ask how important our constant-horizon projections of the interest rates are for the results. To do so, we use the average projected interest which is closest to being 12, 24 and 36 months ahead. (Thus, we use the second series in Figure 6 rather than the first in the case m =24.)

The results in Table 4 show that only the unemployment rate is a significant determinant of the interest rate projection in the case of m = 12. As with the baseline model, the unemployment rate and growth in non-farm payrolls are the only significant determinants in the cases of m = 24 and 36. Furthermore, the r-squareds are lower for the case of m = 12 and also, but less so, for the case m = 24. This suggests that our approach reduces the amount of measurement error in the dependent variable.

Finally, we use FOMC members' forecasts of economic variables as regressors. The FOMC make projections for the unemployment rate, GDP growth, PCE inflation and core inflation.[15] They are therefore similar to the macroeconomic data we used previously, with the exception of non-farm payrolls, which is replaced by real GDP.[16] In order to match the horizons, we use the FOMC's nearest projection horizon to m = 12, 24 and 36 for the macroeconomic variables.

The results are presented in Table 5; a similar pattern to the baseline model in Table 3 emerges. Thus, at m = 12, headline inflation is insignificant but the projections for core inflation, the unemployment rate and real GDP growth all are significant. Furthermore, as in the baseline case, for m = 24, 36, neither of the inflation measures is significant. Rather the unemployment rate is the only significant variable at m = 24 and the real GDP growth rate is the only significant variable (although the sign is not as expected) in the case of m = 36.

5. Conclusions

The FOMC's interest rate projections are eagerly awaited and studied by financial market participants. In particular, the 'dot plots' of interest rate projections are seen as providing important information on future path of policy. They also show just how uncertain FOMC members are about the outlook for monetary policy, although few commentators focus on this.

In this paper we asked how FOMC members' views of the future path of appropriate monetary have evolved over time and how they respond to changes in the

[15] We use the midpoint of the 'central tendency' of projections for the period to March 2015. Thereafter, the median of the projections were made available, and we use these.

[16] We do not use real GDP in the main analysis as it is available with a lag: GDP for the first quarter would only be available to FOMC members when they are making their September projections.

macroeconomic environment. To do so, we first quantify the amount of variation in FOMC members' views of appropriate monetary policy. We then estimate a simple empirical model which allows us to interpolate the path of interest rates the FOMC members, on average, believe is appropriate to achieve their policy objectives. We compute the average view of the appropriate interest rate at constant maturities of one, two and three years, and end by studying how these views respond to current macroeconomic conditions.

We draw four main conclusions from our econometric work. First, it seems desirable to interpolate the data in the 'dot plots' to obtain an average projected path of interest rates. Second, the simple logit equation we use seems to do an acceptable job in this regard. Third, in the specific sample that we study it appears that FOMC members' interest rate projections have been much more sensitive to labour market conditions than to inflation rates, particularly at longer horizons. Fourth, this result is robust to a number of checks.

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Table 1: Coefficients and standard errors

	m_0	σ	R-squared
January 2012	45.043	0.089	0.88
	(2.431)	(0.004)	
April 2012	42.211	0.081	0.88
	(2.685)	(0.005)	
June 2012	46.251	0.070	0.89
	(3.816)	(0.005)	
September 2012	36.460	0.093	0.74
	(2.327)	(0.005)	
December 2012	48.916	0.066	0.82
	(3.969)	(0.004)	
March 2013	45.617	0.072	0.83
	(3.805)	(0.005)	
June 2013	38.757	0.091	0.91
	(1.824)	(0.004)	
September 2013	35.962	0.106	0.82
	(1.480)	(0.004)	
December 2013	34.029	0.112	0.83
	(1.365)	(0.004)	
March 2014	29.114	0.135	0.84
	(1.187)	(0.005)	
June 2014	24.806	0.146	0.80
	(1.258)	(0.006)	
September 2014	20.832	0.173	0.83
	(1.049)	(0.008)	
December 2014	19.340	0.186	0.85
	(0.931)	(0.008)	
March 2015	19.919	0.169	0.81
	(0.964)	(0.007)	
June 2015	19.121	0.171	0.84
	(0.898)	(0.007)	
September 2015	18.125	0.169	0.85
	(0.909)	(0.007)	
December 2015	17.120	0.186	0.89
	(0.719)	(0.007)	
March 2016	16.987	0.117	0.88
	(0.803)	(0.004)	
June 2016	17.905	0.121	0.81
	(1.080)	(0.006)	

Note: Standard errors in parenthesis.

Table 2: Macroeconomic determinants of 1-, 2- and 3-year interest rate projections, macro variables reflect publication dates, January 2011-June 2016

	One-year	Two-year	Three-year
	Univariate results		
PCE inflation	-0.26	-0.75	-0.73
	(0.05)	(0.13)	(0.15)
R-squared	0.40	0.45	0.41
Core PCE inflation	-0.53	-1.82	-2.05
	(0.27)	(0.76)	(0.64)
R-squared	0.16	0.26	0.31
Unemployment rate	-0.21	-0.57	-0.56
	(0.03)	(0.07)	(0.10)
R-squared	0.84	0.85	0.76
Non-farm payroll growth	0.87	3.04	3.04
	(0.18)	(0.39)	(0.51)
R-squared	0.37	0.61	0.56
	Multivariate results		
PCE inflation			
Core PCE inflation	0.46		
	(0.11)		
Unemployment rate	-0.26	-0.44	-0.43
	(0.03)	(0.04)	(0.10)
Non-farm payroll growth		1.29	1.33
		(0.24)	(0.57)
R-squared	0.91	0.91	0.83

Note: Standard errors in parenthesis.

Table 3: Macroeconomic determinants of 1-, 2- and 3-year interest rate projections, first lag of macro variables, January 2011-June 2016

	One-year	Two-year	Three-year
PCE inflation	-0.22		
	(0.10)		
Core PCE inflation	0.84		
	(0.25)		
Unemployment rate	-0.20	-0.44	-0.43
	(0.03)	(0.04)	(0.10)
Non-farm payroll growth		1.29	1.33
		(0.24)	(0.57)
R-squared	0.92	0.91	0.83

Note: Standard errors in parenthesis.

Table 4: Macroeconomic determinants of FOMC members' interest rate projections, macro variables reflect publication dates, January 2011-June 2016

	Closest projection to one-year ahead	Closest projection to two-years ahead	Closest projection to three-years ahead
PCE inflation			
Core PCE inflation			
Unemployment rate	-0.24	-0.39	-0.43
	(0.04)	(0.07)	(0.11)
Non-farm payroll growth		1.34	1.45
		(0.58)	(0.62)
R-squared	0.57	0.78	0.82

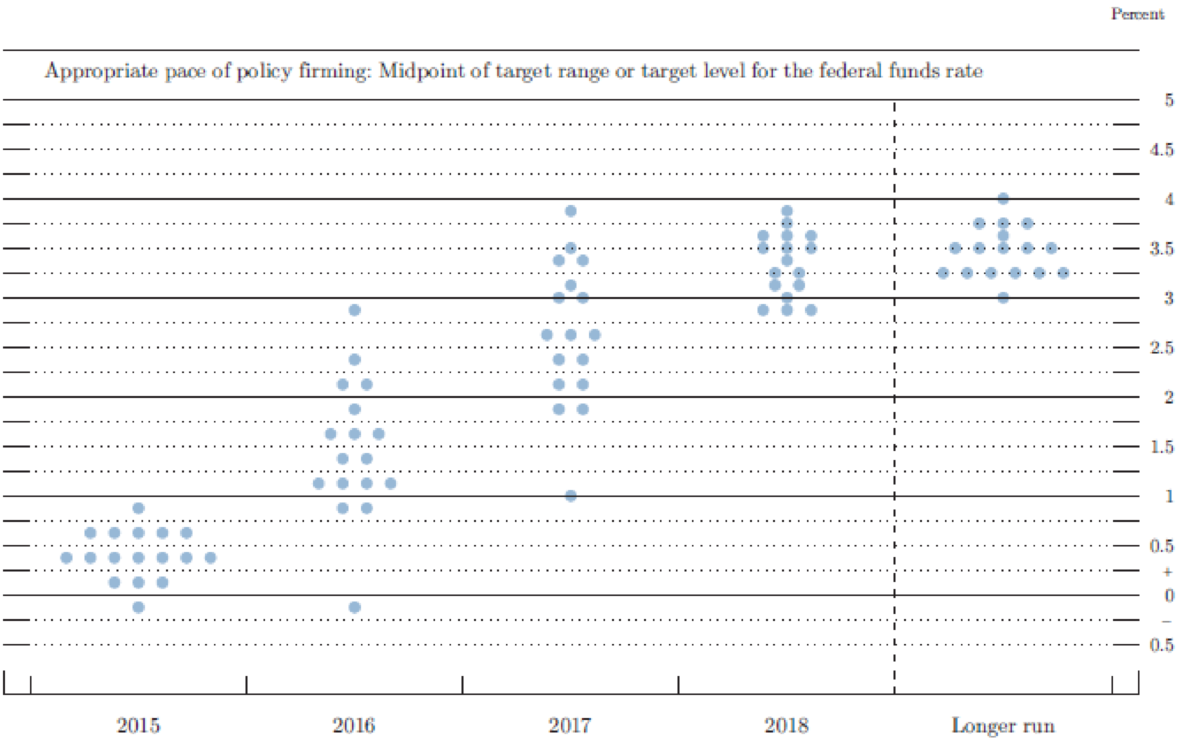
Note: Standard errors in parenthesis.

Table 5: FOMC members' macroeconomic projections as determinants of one, two and three year interest rate projections, January 2011-June 2016

	One-year	Two-years	Three-years
PCE inflation projection			
Core PCE inflation projection	0.40 (0.07)		
Unemployment rate projection	-0.21 (0.02)	-0.62 (0.08)	
Real GDP growth projection	-0.25 (0.05)		-1.23 (0.18)
R-squared	0.92	0.81	0.76

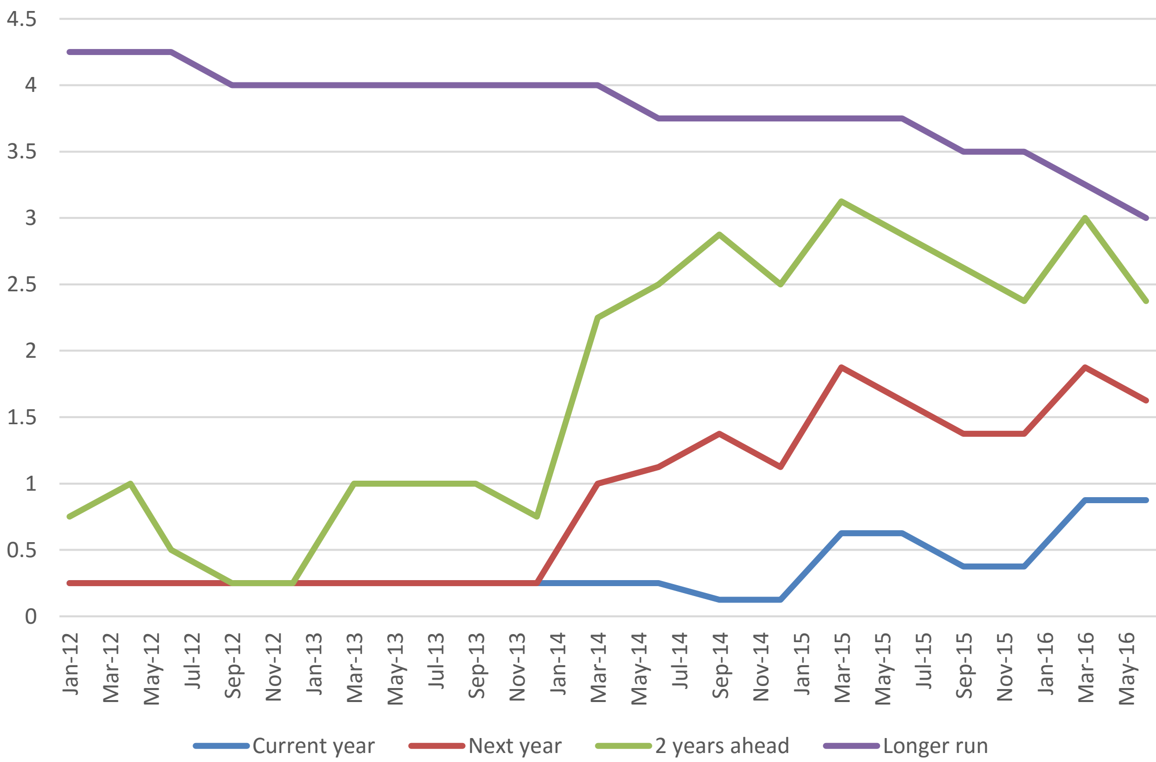
Note: Standard errors in parenthesis.

Figure 1: 'Dot plot' of FOMC members' interest rate projections published following September 2015 meeting



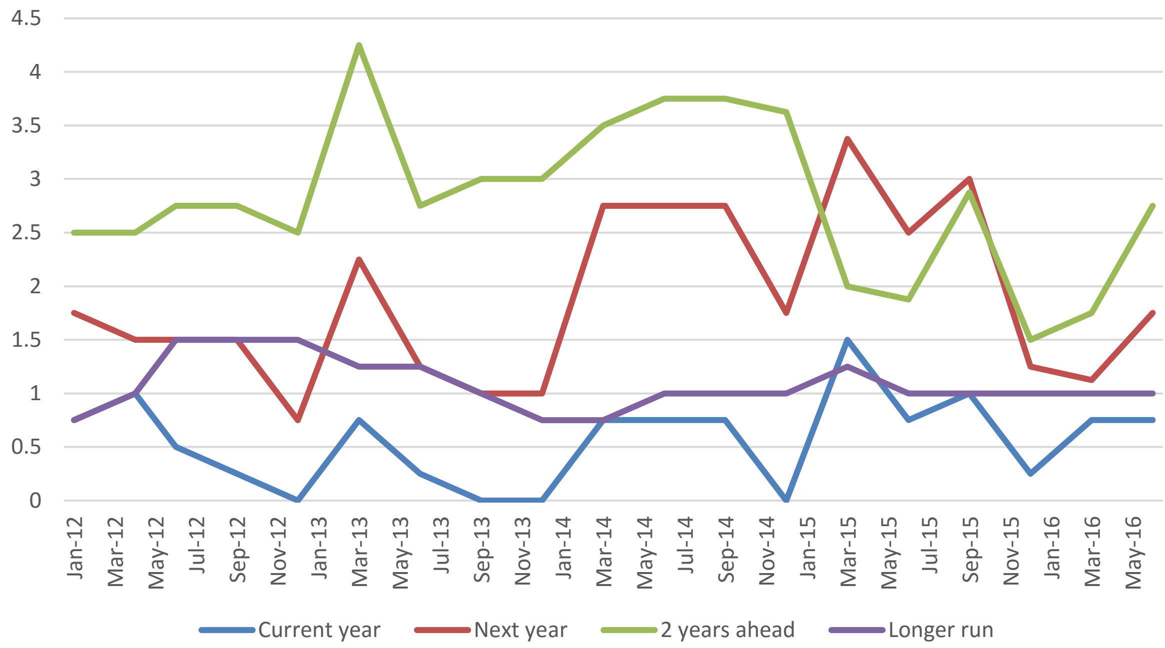
Source: FOMC projection materials, September 2015.

Figure 2: Median projections at each meeting



Note: the three-years ahead projection, which is made in September and December only, has been omitted as it is not continuous.

Figure 3: Range of projections at each horizon



Note: the three-years ahead projection, which is made in September and December only, has been omitted as it is not continuous.

Figure 4: Fitted curve, 95% confidence band, and median projection, September 2015

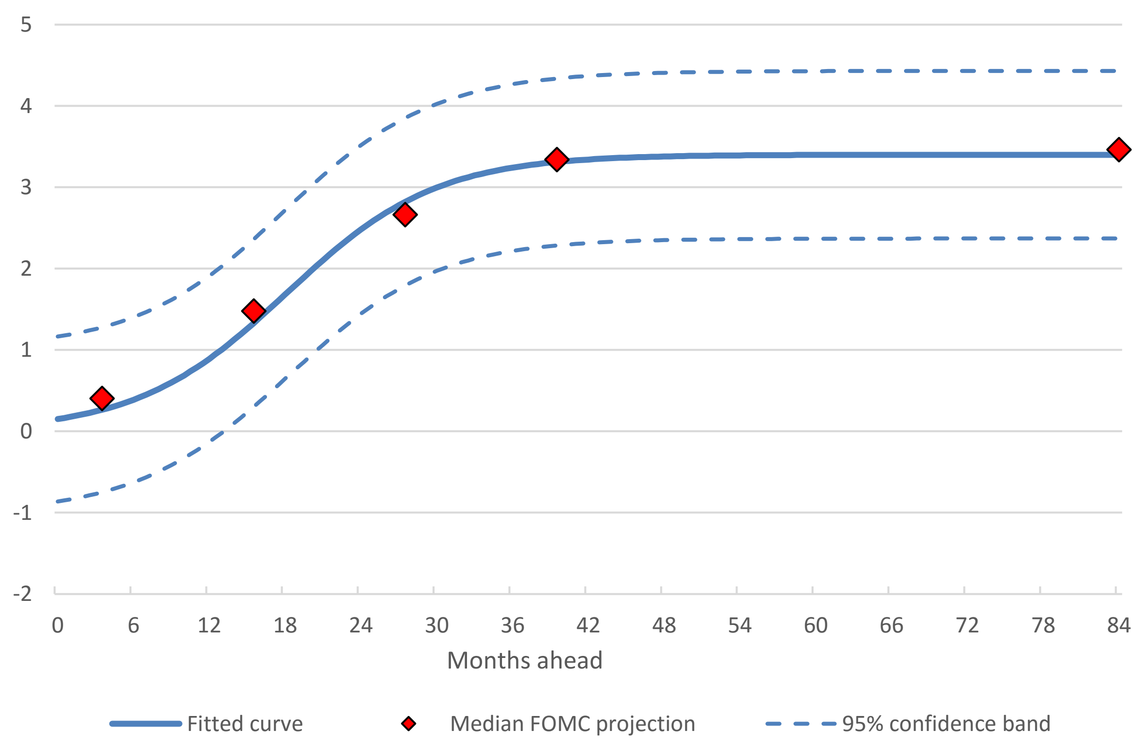


Figure 5: Estimated interest rate curves

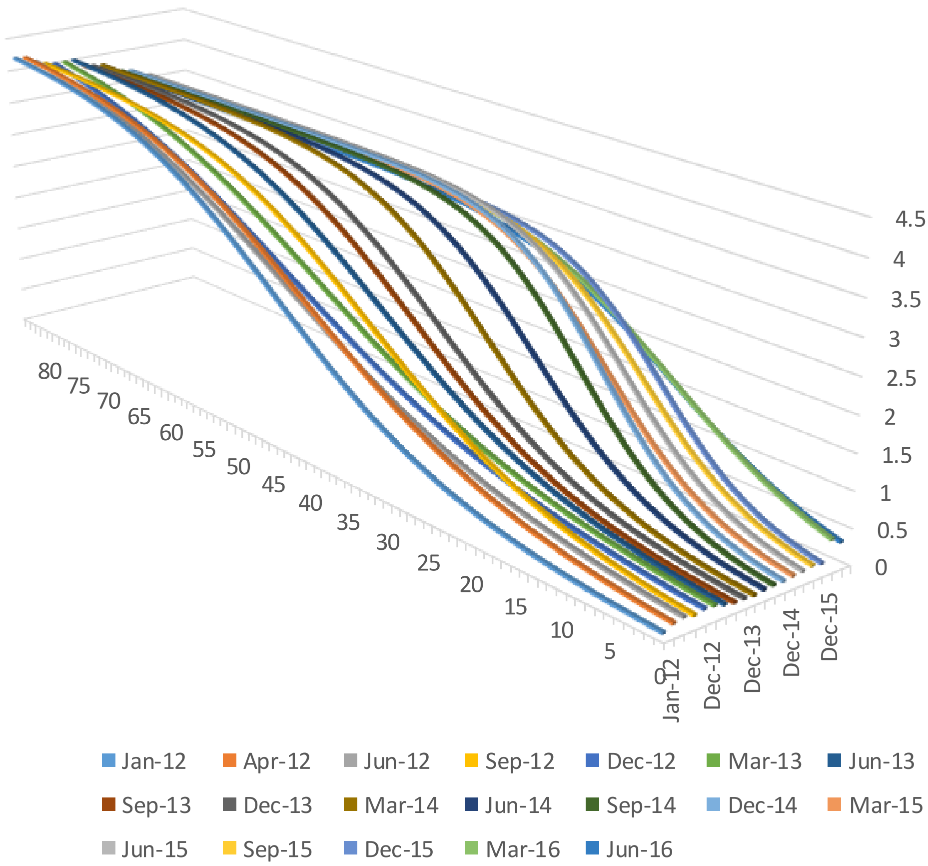


Figure 6: Fitted values for 2 years ahead, and nearest FOMC projection horizon