The FOMC's New Individual Economic Projections and Macroeconomic Theories*

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Abstract

This paper examines whether the economic projections made by individual policymakers of the Federal Open Market Committee (FOMC) are consistent with macroeconomic facts and theories. By analyzing the projections between 2007 and 2016, this paper finds that they are consistent with Okun's law, revealing a significantly negative relationship between unemployment and output growth projections. The relationship between inflation and unemployment projections associated with the Phillips curve is much weaker and more dispersed. The FOMC's reaction function is estimated to be consistent with a conventional Taylor rule, with a sufficiently aggressive response to the inflation gap satisfying the Taylor principle and a negative response to the unemployment gap.

Keywords: FOMC, Individual Economic Projections, Okun's Law, Phillips Curve, Taylor Rule

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1 Introduction

Recently, central banks' communications have become increasingly important in the conduct of monetary policy. This was particularly the case when many advanced economies experienced the effective lower bound (ELB) following the financial crisis of 2008–2009 and the COVID-19 crisis in 2020. Since 2007, the Federal Open Market Committee (FOMC) has published a Summary of Economic Projections (SEP) made by individual policymakers, which has become one of the most important communication tools for the Federal Reserve (Fed). According to a survey conducted by Olson and Wessel (2016), nearly half of Fed watchers from both academia and the private sector regard the SEP as useful. However, there is one caveat to this: As only a summary of the projections, such as the range and central tendency, is available at the time of FOMC meetings, only variable-by-variable summaries of the projections are observed.[1] As a result, it is impossible for the public to associate the projections of different macroeconomic variables or the macroeconomic projections with the appropriate paths of monetary policy.

In this paper, I overcome this shortcoming by using a new data set of the FOMC participants' anonymous individual economic projections between 2007 and 2016 to examine two research questions. First, I investigate the empirical properties of the FOMC's individual economic projections and assess whether they are consistent with standard macroeconomic facts and theories, such as Okun's law and the Phillips curve. As FOMC policymakers are highly experienced macroeconomists, with access to a vast array of staff and resources to direct economic research at the Fed, it is crucial to evaluate whether their individual projections are consistent with textbook macroeconomic relationships. Second, this paper investigates the reaction function of the FOMC, which characterizes its monetary policy decisions in response to changing economic conditions, as discussed in Bernanke (2016). More specifically, I estimate the Taylor rule based on the inflation and unemployment gaps—deviations of inflation and unemployment rates from their natural levels—using the FOMC's individual economic projections. There are several advantages to using these individual projections. The FOMC publishes all the relevant projections to estimate the reaction function, including projections of the federal funds rate and long-run macroeconomic projections.

[1] For an assessment based on the aggregate summary of economic projections, see Arai (2016) and Kalfa and Marquez (2019).

These projections enable us to compute the inflation and unemployment gaps with which we can directly estimate the FOMC's reaction function. In addition, there are substantial variations in the FOMC's individual projections for longer horizons, even though the actual federal funds rate remained at the ELB for most of the sample period.[2]

To answer these questions, this paper employs regressions based on repeated cross-sectional data. I assume that FOMC policymakers have the same coefficients in each regression to capture their collective macroeconomic principles. This is because estimating the collective principles is useful as a benchmark, given that the FOMC's decisions are based on consensus, and the principles tested in this paper are widely accepted in macroeconomics. I first run the regressions at each forecast horizon, from one to fourteen quarters ahead, to account for the different nature of forecasting across horizons. Then, I provide the pooled regression combining all horizons with the horizon- and meeting-fixed effects. For the estimation of the FOMC's reaction function, I apply the censored regression (Tobit) model to account for the nonlinearity associated with the ELB.

The results indicate that the FOMC's individual projections are consistent with Okun's law—the association between output growth and the unemployment rate is strongly negative and statistically significant. Although the relationship between unemployment and inflation (i.e., the Phillips curve) is negative and statistically significant, the relationship is weak and dispersed. The estimates of the reaction function indicate that the FOMC's individual economic projections are consistent with a conventional Taylor rule. The equilibrium real interest rate and the response to the inflation gap are estimated to be positive and statistically significant. In particular, the magnitude of the response to the inflation gap is larger than one in most cases, consistent with the Taylor principle that a central bank should be sufficiently aggressive against inflation to maintain stability. The response to the unemployment gap is significantly negative in all specifications, consistent with the dual mandate of the Fed.

This paper offers two extensions to the main results. First, I analyze the consistency of the Survey of Professional Forecasters (SPF) with Okun's law and the Phillips curve during the same sample period using the SPF's individual forecasts. Similar to the FOMC's forecasts, I find a robust Okun's law relationship and a weak Phillips curve relationship, which suggests that these tendencies

[2] Bundick (2015), Pierdzioch et al. (2016), and Kim and Pruitt (2017) also exploited this advantage of survey forecasts to estimate the reaction function.

are likely driven by the sample period rather than by the factors specific to the forecasters. Second, I use the FOMC's output gaps instead of the unemployment gaps to estimate the FOMC's reaction function. The evidence is mixed when output gaps are used for the estimation, but this is likely due to downward revisions of the longer-run projections for output growth during the sample period.

These results are largely consistent with the existing literature. Several papers find that Okun's law serves as a useful guide for forecasters.[3] Given the significance of Okun's law for forecasting, it is natural to find this robust relationship between output growth and unemployment rate projections. Conversely, several papers have documented that the forecasting performance of the models based on the Phillips curve has deteriorated over the years, as discussed in Stock and Watson (2008) and Faust and Wright (2013). In particular, many papers claim that the Phillips curve has flattened in recent decades.[4] Therefore, it is not surprising that the observed correlation between inflation and unemployment projections made by FOMC policymakers and private forecasters is weak. Casey (2020) reached the same conclusion by studying professional survey forecasts in the US, UK, and Europe. Finally, the estimates of the FOMC's reaction function are consistent with the estimates in earlier papers by Kahn and Palmer (2016) and Morris (2017), which were based on the FOMC's aggregate SEP, and by Belongia and Ireland (2019), which was based on the Fed's Greenbook forecasts.

The contribution of this paper is twofold. First, it is one of the first attempts to investigate the empirical properties of the FOMC's new individual economic projections, which have attracted renewed interest since 2007.[5] Since the FOMC began to publish them as one of its primary communication tools, the analysis of these new projections is particularly relevant for monetary policy. Similar to the papers by Carvalho and Nechio (2014), Dräger et al. (2016), and Tillmann (2010), which studied the consistency of survey expectations with macroeconomic facts and theories, this

[3] For example, see Ball et al. (2015), Guisinger and Sinclair (2015), Mitchell and Pearce (2010), and Pierdzioch et al. (2011). In fact, Jordà et al. (2020) show that a simple model incorporating Okun's law can help refine the advance data release of real GDP, even during the COVID-19 pandemic.

[4] For example, see Del Negro et al. (2020), Gagnon and Collins (2019), Hooper et al. (2020), Jorgensen and Lansing (2019), Kuttner and Robinson (2010), Matheson and Stavrev (2013), and Simon et al. (2013).

[5] For the analysis of the FOMC's individual economic projections prior to 2007, see Meade and Sheets (2005), Nakazono (2013), Romer (2010), Sheng (2015), and Tillmann (2011). According to Powell and Wessel (2020), more than 60% of survey respondents answered that SEP is useful, while only 20% of them answered so for monetary policy reports to Congress that published the projections prior to 2007.

paper confirms that the FOMC's individual economic projections are broadly consistent with these facts and theories. Second, this paper provides quantitative estimates of the FOMC's reaction function at the ELB, exploiting the variation at longer-horizon forecasts. Given that investors pay substantial attention to the FOMC's communication, which has significant impacts on various asset prices,[6] providing quantitative estimates of the FOMC's reaction function could be useful. Even though the Fed engaged in unconventional monetary policy at the ELB rather than the conventional policy characterized by the reaction function, the quantitative estimates will be particularly valuable when the liftoff of interest rates is expected near the end of the ELB.

The remainder of this paper is organized as follows: Section 2 describes the data and methods used. Section 3 presents the main empirical results, and Section 4 provides extensions to the main results. Section 5 offers concluding remarks.

2 Methodology

In this section, I first explain the details of the FOMC's individual economic projections. Second, I explain the calculation of the annual changes in the unemployment projections used in the analysis. Third, I describe the test to determine whether the FOMC's individual economic projections are consistent with Okun's law. Fourth, I set out a similar test for the Phillips curve. Finally, I describe the estimation of the FOMC's reaction function.

2.1 Data

The FOMC's economic projections are the numerical projections of several macroeconomic series over the next two to three years and over the longer run:[7] real GDP growth, the unemployment rate, PCE inflation, and core PCE inflation. Since 2012, the FOMC has started publishing the projected path of the future federal funds rate associated with these macroeconomic projections.

The FOMC's economic projections are the annual projections that target the level or growth rate in the fourth quarter of a given year. Although all the participants of the FOMC meetings submit their projections, only a set of summary statistics are released immediately after the meeting, such

[6]For recent discussions, see Bodilsen et al. (2021), Couture (2021), Du et al. (2018), and Indriawan et al. (2021).
[7]The projections over the longer run were added in 2009.

as the ranges, central tendency, and median.[8] The FOMC releases these projections four times a year, typically in March, June, September, and December.

Recently, individual FOMC policymakers' economic projections have been made available to the public with a five-year lag, and the projections from 2007 to 2016 are currently available. These individual projections are anonymous, and the policymakers are identified by randomly assigned numbers, which are reshuffled at every meeting. Therefore, researchers can analyze the variations in the projections made at each meeting across different macroeconomic variables.

2.2 Calculation of Annual Changes

The FOMC's economic projections are in the form of growth rates for real GDP growth, PCE inflation, and core PCE inflation, whereas they are based on the levels for the unemployment rate. For a regression analysis, it is convenient to compute the annual changes in the unemployment rate.

First, I denote the forecast of the unemployment rate made by forecaster i at the qth quarters of year t forecasting h years ahead ($h = 0, \ldots, 3$) as $\hat{U}^i_{t+h|t,q}$. Then, I compute the forecasts of the annual change relative to the previous year as follows:

$$\Delta \hat{U}^i_{t+h|t,q} \equiv \begin{cases} \hat{U}^i_{t|t,q} - U_{t-1|t,q} & \text{for } h = 0 \\ \hat{U}^i_{t+h|t,q} - \hat{U}^i_{t+h-1|t,q} & \text{for } h = 1, 2, 3, \end{cases} \tag{1}$$

where $U_{t-1|t,q}$ is the real-time realized value of year $t-1$ observed at the qth quarters of year t. In other words, I calculate the annual changes by taking the difference between the real-time realized value and the projections for the nowcasts ($h = 0$) and computing the incremental changes in the projections for the subsequent forecasts ($h = 1, 2, 3$).

Figure 1 depicts the calculation of the annual changes. For illustration, suppose that the forecasts are made at the second quarter of year t. Then, the forecasts for the fourth quarter of year ($h = 0$) and for the fourth quarter of the next year ($h = 1$) by forecaster i are denoted as $\hat{U}^i_{t|t,2}$ and $\hat{U}^i_{t+1|t,2}$, respectively. By taking the difference between them, I effectively compute the forecast of the annual changes between year t and year $t+1$ made at the second quarter,

[8] The FOMC began to release median projections in September 2015.

$\Delta\hat{U}^i_{t+1|t,2} = \hat{U}^i_{t+1|t,2} - \hat{U}^i_{t|t,2}$. For the forecast of the fourth quarter of the same year, the annual change is computed by taking the difference between the forecast and the real-time realized value of the previous year, $\Delta\hat{U}^i_{t|t,2} = \hat{U}^i_{t|t,2} - U_{t-1|t,2}$.

2.3 Test for Okun's Law

Okun's law shows a negative relationship between changes in the unemployment rate and output growth, which characterizes a short-run fluctuation of the economy:

$$\Delta U_t = \alpha - \beta\Delta Y_t, \tag{2}$$

where ΔU_t is the change in the level of the unemployment rate and ΔY_t is the growth rate of output. Typically, we assume the coefficient, α, to be 1.5% and the magnitude of the slope, β, to be 0.5 for the US economy.[9]

It is straightforward to test whether the FOMC individual policymaker's projections are consistent with Okun's law using the following regression:

$$\Delta\hat{U}^i_{t+h|t,q} = \alpha_{h,q} - \beta_{h,q}\Delta\hat{Y}^i_{t+h|t,q} + \varepsilon^i_{t+h|t,q}, \tag{3}$$

where $\Delta\hat{U}^i_{t+h|t,q}$ is the forecast of the changes in the unemployment rate made by forecaster i at the qth quarters of year t forecasting h years ahead, and $\Delta\hat{Y}^i_{t+h|t,q}$ is the corresponding forecast for GDP growth.

To investigate the collective principle of the FOMC, I assume that the policymakers share the same parameters in the regression. Even though this is arguably a strong assumption, given that a substantial degree of heterogeneity is observed among FOMC policymakers,[10] I maintain it for two reasons. First, since the FOMC collectively makes monetary policy decisions based on consensus, estimating the FOMC's collective principle is useful as a benchmark for the public. Second, the macroeconomic facts and theories tested in this paper are widely accepted in macroeconomics

[9] For example, see Mankiw (2018).

[10] For a critical review of the FOMC's communications and their dispersion among policymakers, see Faust (2016). Vissing-Jorgensen (2019) propose several reforms to the FOMC's communications because FOMC policymakers strategically use their communications to influence the consensus, which eventually confuses investors.

and FOMC policymakers largely agree with these facts and theories.[11] In other words, FOMC policymakers' dispersions are likely driven by their views on the state and the future course of the economy, rather than by their views on macroeconomic facts and theories.

Using this specification, I first run separate regressions for each combination of the forecast horizons and the quarters, which range from nowcast ($h = 0$ and $q = 4$: forecasting the fourth quarter of the year at the same quarter) to fourteen quarters ahead ($h = 3$ and $q = 3$: forecasting the fourth quarter three years ahead at the third quarter of a year). It is natural to separate the sample according to the forecast horizons, since the nature of forecasting practice likely differs depending on the length of the forecast horizons.

Second, I pool the forecasts across all horizons to estimate the coefficients by controlling for the effects at specific meetings:

$$\Delta \hat{U}^i_{t+h|t,q} = \alpha - \beta \Delta \hat{Y}^i_{t+h|t,q} + \sum_{t=2007}^{T} \sum_{q=1}^{Q} \delta_{t,q} D_{t,q} + \varepsilon^i_{t+h|t,q}, \tag{4}$$

where $D_{t,q}$ is the dummy variable for a specific FOMC meeting, and T and Q denote the last year of the sample and the maximum number of quarters, respectively. The dummy variable aims to control for the effects of news at each FOMC meeting, which could affect all the forecasts across different horizons made at the same meeting. Alternatively, the dummy variable for individual forecast horizons, $D_{h,q}$, could be included to control for the horizon fixed effects.

2.4 Test for the Phillips Curve

The test for the Phillips curve, which describes a trade-off between inflation and unemployment, is constructed in a similar manner. A typical Phillips curve is defined in gap form as follows:

$$\pi_{t+h} = E_t[\pi_{t+h}] - \theta(U_{t+h} - U^n_{t+h}) + v_t, \tag{5}$$

[11] For example, Tillmann (2010) finds that the slope of the Phillips curve is not materially different between the governors of the Federal Reserve and regional Reserve Bank Presidents. Fendel and Rülke (2012) and Jung and Latsos (2015) reach similar conclusion for the FOMC's reaction function.

where π, U^n, and v denote the rate of inflation, the natural rate of unemployment, and the supply shock, respectively.[12] To describe the test for the Phillips curve, I introduce new notations. I denote $E^i_{t,q}[\pi_{t+h}] = \int f^i(\pi_{t+h}|\Omega_{t,q})\pi_{t+h}d\pi_{t+h}$ as the expected inflation rate h years ahead by policymaker i, where $f^i(\pi_{t+h}|\Omega_{t,q})$ is the probability density assigned by policymaker i to inflation h years ahead conditional on the information set $\Omega_{t,q}$.

This specification of the Philips curve could be tested by taking the first-order differences of the projections as follows:

$$\Delta\hat{\pi}^i_{t+h|t,q} = \gamma_{h,q} - \theta_{h,q}\Delta\hat{U}^i_{t+h|t,q} + \nu^i_{t+h|t,q}, \tag{6}$$

where $\Delta\hat{\pi}^i_{t+h|t,q}$ is defined in the same way as in Equation (1). Note that $\gamma_{h,q} \equiv \left(E^i_{t,q}[\pi_{t+h}] - E^i_{t,q}[\pi_{t+h-1}]\right) + \theta_{h,q}\left(\hat{U}^{n,i}_{t+h|t,q} - \hat{U}^{n,i}_{t+h-1|t,q}\right)$, which combines the annual changes of inflation expectations and the natural rate of unemployment at the same meeting. For simplicity, I assume that $\gamma_{h,q}$ is constant, which implies that policymaker i does not change the paths of their inflation expectations and the forecasts of the natural rate of unemployment across horizon h and $h-1$ at each FOMC meeting. Similar to the test of Okun's law, I assume that both the constant and coefficients are the same across individual policymakers.

Following the same method outlined in the regression that tests Okun's law, I pool the forecasts across all horizons by adding the fixed effects for each FOMC meeting,

$$\Delta\hat{\pi}^i_{t+h|t,q} = \gamma - \theta\Delta\hat{U}^i_{t+h|t,q} + \sum_{t=2007}^{T}\sum_{q=1}^{Q}\delta_{t,q}D_{t,q} + \nu^i_{t+h|t,q}, \tag{7}$$

where $D_{t,q}$ is the dummy variable for a specific FOMC meeting, and T and Q denote the last year of the sample and the maximum number of quarters, respectively.

2.5 Estimating the FOMC's Reaction Function

The reaction function of FOMC policymakers characterizes their monetary policy decisions in response to changing economic conditions by taking the trade-offs in their policy objectives into

[12] For example, see Mankiw (2018).

account. The FOMC's new individual economic projections offer several advantages for estimating the reaction function. First, since FOMC policymakers publish their inflation and unemployment rate projections in the longer run, along with their fixed-target forecasts, researchers can directly measure the inflation and unemployment gaps as the difference between them. Second, the estimation will not be constrained by the ELB because forecasts of future interest rates could be positive at sufficiently long forecast horizons, even though the short-term federal funds rate was stuck at the ELB between 2012 and 2015. Therefore, individual FOMC policymakers' projections will offer researchers substantial variation in their estimations.

Typically, the FOMC's reaction function is described by the Taylor rule, in which the optimal interest rate depends on the inflation and output gaps, the latter of which can be measured by the unemployment gap using Okun's law. In this paper, I use the Taylor rule based on the unemployment gap as the main specification:[13]

$$i_{t+h} = \rho + \phi^{\pi}(\pi_{t+h} - \pi^*) - \phi^{U}(\Delta U_{t+h} - \Delta U^n_{t+h}), \tag{8}$$

where i_t is the nominal interest rate, π^* is the target inflation rate, and U^n_{t+h} is the natural rate of unemployment. The constant, ρ, could be interpreted as the equilibrium real interest rate that would prevail when both the inflation and unemployment gaps are closed. Using FOMC policymakers' inflation and unemployment rate projections in the longer run, I characterize the forecasts of a hypothetical interest rate implied by the Taylor rule as $\tilde{i}^i_{t+h|t,q}$, which would not be constrained by the ELB:

$$\tilde{i}^i_{t+h|t,q} = \rho_{h,q} + \phi^{\pi}_{h,q}(\hat{\pi}^i_{t+h|t,q} - \hat{\pi}^i_{LR|t,q}) - \phi^{U}_{h,q}(\Delta\hat{U}^i_{t+h|t,q} - \Delta\hat{U}^i_{LR|t,q}) + \varepsilon^i_{t+h|t,q}, \tag{9}$$

where the subscript LR denotes the projections over the longer run. Similar to the tests of Okun's law and the Phillips curve, I assume that both the constant and coefficients are the same across individual policymakers. To account for the nonlinearity of the federal funds rate associated with the ELB, I assume that the published forecasts of the federal funds rate, $\hat{i}^i_{t+h|t,q}$, are censored at

[13] For example, see Chapter 3 of Galí (2015). The results based on the output gap are discussed in Section 4.2.

zero as follows:

$$\hat{i}^i_{t+h|t,q} = \begin{cases} \tilde{i}^i_{t+h|t,q} & \text{if } \tilde{i}^i_{t+h|t,q} > 0, \\ 0 & \text{if } \tilde{i}^i_{t+h|t,q} \leq 0. \end{cases} \tag{10}$$

In other words, we only observe the forecasts of the Taylor-rule implied policy rate $\tilde{i}^i_{t+h|t,q}$ when it is positive. To estimate this model, I apply the Tobit model following Kim and Pruitt (2017).[14] The likelihood for a given forecast horizon h and quarter q is written as follows:

$$\begin{aligned} L_{h,q} = & \prod_{i=1}^{N} \prod_{t \in T^{i,0}_{h,q}} \left(1 - \Phi \left[\frac{\rho_{h,q} + \phi^{\pi}_{h,q}(\hat{\pi}^i_{t+h|t,q} - \hat{\pi}^i_{LR|t,q}) - \phi^{U}_{h,q}(\Delta \hat{U}^i_{t+h|t,q} - \Delta \hat{U}^i_{LR|t,q})}{\sigma} \right] \right) \\ \times & \prod_{i=1}^{N} \prod_{t \notin T^{i,0}_{h,q}} \left(\frac{1}{\sigma} \varphi \left[\frac{\hat{i}^i_{t+h|t,q} - \rho_{h,q} + \phi^{\pi}_{h,q}(\hat{\pi}^i_{t+h|t,q} - \hat{\pi}^i_{LR|t,q}) - \phi^{U}_{h,q}(\Delta \hat{U}^i_{t+h|t,q} - \Delta \hat{U}^i_{LR|t,q})}{\sigma} \right] \right), \end{aligned} \tag{11}$$

where Φ and φ denote the cumulative distribution function and probability density function of the normal distribution, and N denotes the number of policymakers. $T^{i,0}_{h,q}$ is defined as the set of samples where the ELB becomes binding, namely, $T^{i,0}_{h,q} \equiv \{t = 1, \ldots, T : \hat{i}^i_{t+h|t,q} = 0\}$. The parameters are estimated by maximizing the likelihood.

Following the same method outlined in the tests for Okun's law and the Phillips curve, this regression could be estimated by pooling the forecasts across all horizons and adding the fixed effects for each FOMC meeting as follows:

$$\tilde{i}^i_{t+h|t,q} = \rho + \phi^{\pi}(\hat{\pi}^i_{t+h|t,q} - \hat{\pi}^i_{LR|t,q}) - \phi^{U}(\Delta \hat{U}^i_{t+h|t,q} - \Delta \hat{U}^i_{LR|t,q}) + \sum_{t=2007}^{T} \sum_{q=1}^{Q} \delta_{t,q} D_{t,q} + \varepsilon^i_{t+h|t,q}, \tag{12}$$

where $D_{t,q}$ is the dummy variable for a specific FOMC meeting. By following the same procedure, I obtain the estimates by the maximum likelihood based on the Tobit model.

[14] The methodology is based on Amemiya (1984), the details of which are explained in Section 7.4. of Verbeek (2017). Mavroeidis (2021) proposes a methodology to exploit the nonlinearity associated with the ELB to test the efficacy of unconventional monetary policy.

3 Results

3.1 Okun's Law

Figure 2 shows the scatter plot of the changes in the unemployment rate and GDP growth with the corresponding fitted line. It is evident from the figure that there is a strong negative correlation between the forecasts of output growth and changes in the unemployment rate, which implies that the FOMC's economic projections are consistent with Okun's law. The estimates of the regression analysis, summarized in Table 1, confirm this observation. The estimates of the constant and coefficient are 1.12 and −0.56 for the pooled regression, 1.41 and −0.55 for the regression with the fixed effects for the FOMC meetings, as described in Equation (4), and 1.03 and −0.63 for the regression with the fixed effects for the forecast horizons, all of which are statistically significant. These estimates suggest that the FOMC's economic projections closely follow conventional Okun's law, with a constant of 1.5 and a slope of −0.5. The Wald test strongly rejects the null hypothesis that the values of the coefficients are all zero. The adjusted R^2 are quite high, and approximately 70% of the variation is explained by the Okun's law regression.

Figure 3 shows the estimated slope coefficients of Okun's law at each quarterly horizon, as described in Equation (3), with the corresponding standard errors. Although the magnitudes of the estimates at the horizons within a year tend to be significantly larger than the conventional value of 0.5, they converge around 0.5 at the longer horizons. The larger magnitudes of the estimates at the shorter horizons likely reflect the rapid increase and gradual decline of the unemployment rate during and after the Great Recession.

3.2 The Phillips Curve

Figure 4 shows the scatter plot of the changes in inflation and the unemployment rate with the corresponding fitted line in which inflation is measured by PCE or core PCE. Unlike the test for Okun's law, the association between inflation and unemployment projections is much weaker, with many observations deviating substantially from the fitted line for both measures of inflation. Table 2 summarizes the results of the regression analysis, and they are consistent with this observation. The estimated slopes of the Phillips curve are between −0.21 and −0.20 for PCE inflation and between -0.17 and -0.16 for core PCE inflation, both of which are statistically significant. The estimates of the constant are very close to zero—between -0.07 and -0.02 for PCE inflation and between -0.12 and -0.01 for core PCE inflation—and statistically insignificant in most cases, which does not reject the implication that γ is zero. Although the Wald test significantly rejects the null hypothesis that the values of the coefficients are all zero, the adjusted R^2 are much lower than in the Okun's law regression, and only 6 to 30% of the variation is explained by the Phillips curve regression.

Figure 5 shows the estimated slopes of the Phillips curve at each quarterly horizon, as described in Equation (6), with the corresponding standard errors. The figure shows that the slope of the Phillips curve is approximately -0.1 at most horizons, whereas the magnitude of the estimates between three and seven quarters ahead is substantially larger than the other horizons and with substantially larger standard errors. Although the magnitude of the estimates depends on the measure of inflation, the general pattern of the results is similar. The large estimated coefficients in the medium term likely reflect the fact that inflation was subdued during the Great Recession and the following period of recovery. At the onset of the Great Recession, FOMC policymakers expected inflation to fall dramatically, perhaps reaching close to zero, given the severity of the macroeconomic shock, and they thus predicted a large magnitude of increases in the unemployment rate and reductions in inflation. Similarly, FOMC policymakers predicted that inflation would increase as the unemployment rate gradually declined during the recovery. Although these predictions are likely to have steepened the slope of the Phillips curve over the medium-term horizons, either a sharp fall or rise in inflation did not occur as anticipated.[15] As the target period approaches, FOMC policymakers modify their inflation projections accordingly, which makes the slope suggested by the short-term projections smaller.

3.3 Reaction Function

Figure 6 shows the scatter plot of the federal funds rate, unemployment gap, and inflation gap measured by PCE. As the figure shows, FOMC policymakers expect the federal funds rate to rise

[15] In particular, the fact that inflation did not fall much during the Great Recession is called "missing disinflation." For a detailed discussion, see Ball and Mazumder (2011), Christiano et al. (2015), Coibion and Gorodnichenko (2015), and Gilchrist et al. (2017).

at longer horizons, although it has been stuck at zero in the short term. Table 3 presents the estimates of the reaction function using the whole sample based on the Tobit model. The results show that the estimates of the constant, which may be interpreted as the equilibrium real interest rate, are positive, and their magnitude is between 1.93 and 2.98. The estimated responses to the unemployment gap are significantly negative in all cases, ranging from -0.70 to -0.46, while the estimated responses to the inflation gap are significantly positive at between 0.82 and 2.73. These results suggest that the FOMC's economic projections are broadly consistent with a conventional Taylor rule to achieve the dual mandate of maximizing employment and stabilizing inflation. In particular, the magnitudes of the responses to the inflation gap are larger than one in most cases, which is consistent with the Taylor principle that central banks should be sufficiently aggressive against inflation to maintain stability.[16]

Figure 7 shows the estimated responses to the unemployment and inflation gaps at each quarterly horizon, as described in Equation (9), with the corresponding standard errors. The response to the unemployment gap is close to zero at the short horizons within a year and becomes significantly negative at the longer horizons. The response to the inflation gap is close to zero at the short horizons within a year, and they reach above one at most long-term horizons, although the corresponding standard errors become larger. Given that the short-term interest rate was stuck near zero during most of the sample period, from 2012 to 2015, it is not surprising that the responses to both the inflation and unemployment gaps are estimated to be zero at the short horizons.

4 Extensions

4.1 Comparison with the SPF forecasts

As an extension, I conducted the same analysis using the individual forecasts of the SPF during the same period between 2007 and 2016. One thing to note is that the FOMC's projections and the SPF are not fully comparable due to their designs, and there are several minor differences. First, the SPF's unemployment forecasts target the annual average of the unemployment rate, instead of the value at the fourth quarter targeted by the FOMC. Therefore, the calculation of the annual

[16] For details, see Galí (2015).

changes in the unemployment rate is based on the annual average of the real-time data observed at the time of the forecasts. Second, the maximum horizon of the SPF for real economic variables is four years, whereas the maximum horizon for price levels is three years. Third, the timing of the survey is in the middle of the quarters for the SPF forecasts, while it is typically in the last month of the quarters for the FOMC's projections.

Tables 4 and 5 present the empirical results of Okun's law and the Phillips curve based on the SPF forecasts. The results are generally similar to those obtained using the FOMC's individual projections. For Okun's law, both the constant and slope are significant, with magnitudes close to the conventional values. The estimates of the constants are between 0.99 and 1.24, and the estimated slopes are between -0.60 and -0.48. Adjusted R^2 are relatively high, and more than 60% of the variations are explained by the regression. On the other hand, the Phillips curves found in the SPF forecasts are much weaker and more dispersed. The estimated slopes range from -0.37 to -0.23, and most of the constants are estimated to be insignificant. Although the null hypothesis that all the coefficients are zero is strongly rejected, the explanatory power of the regression is relatively low, with R^2 between 0.13 and 0.24 for PCE inflation and 0.25 and 0.30 for core PCE inflation. These results suggest that empirical patterns found in the FOMC's individual projections—a robust Okun's law relationship and a weak Phillips curve relationship—are likely driven by the sample period rather than factors specific to the forecasters.[17]

4.2 Estimation of the Taylor Rule Based on the Output Gap

Table 6 presents the estimates of the reaction function using the output gap. The results are different from the results based on the unemployment gap in two ways. First, the coefficients of the output gap turn out to be significantly negative in many cases, which is not consistent with a conventional Taylor rule. More specifically, the results imply that a negative output gap is associated with a hike in the federal funds rate. Second, the estimates of the constant and the response to the inflation gap are much more volatile depending on the specification—the estimated constant ranges from 2.00 to 3.20, and the estimated response to the inflation gap ranges from 0.33

[17] For a more detailed comparison of FOMC and other private forecasts, see Bespalova (2020), Ellison and Sargent (2012), Gamber and Smith (2009), Hubert (2014), and Romer and Romer (2000).

to 3.43.

These different estimates likely reflect the changes in output growth projections in the longer run. As indicated in Figure 8, many FOMC policymakers substantially revised down their projections for output growth in the longer run after 2012, when they started to release the projections for the federal funds rate. As the output gap is measured as the difference between the projections targeting a specific year and the projections in the longer run, these revisions in the longer-run projections likely changed the signs of the output gaps. As a result, the estimates of the reaction function became volatile, and the signs of the responses to the output gaps flipped. By studying several survey forecasts from official institutions, Coibion et al. (2018) point out that the estimates of potential output often exhibit cyclical sensitivity in practice, contradicting the prediction from theory. The fluctuation due to such sensitivity had a particularly large impact on the estimation of the FOMC's reaction function because of the short sample period.

5 Conclusion

By analyzing the individual projections made by FOMC policymakers between 2007 and 2016, this paper finds that they are largely consistent with macroeconomic facts and theories. The relationship between output growth and unemployment projections is significantly negative, consistent with Okun's law, and the relationship between inflation and unemployment projections associated with the Phillips curve is weak and more dispersed. This paper also provides the estimates of the FOMC's reaction function, which are consistent with a conventional Taylor rule.

The results set out in this paper indicate that textbook macroeconomic principles served as a useful forecasting guide for FOMC policymakers during the Great Recession and its aftermath. Though the formal analysis is infeasible due to the five-year embargo policy, this tendency has likely persisted during the recent COVID-19 crisis. This paper also demonstrates that the FOMC's individual projections provide researchers with substantially richer variations than those of the SEP, which enhances the understanding of the FOMC's conduct of US monetary policy. Further research on the FOMC's individual economic projections, particularly using the policymakers' identities when they become public, would yield a better understanding of the FOMC's collective decision making, which I leave for a future exercise.

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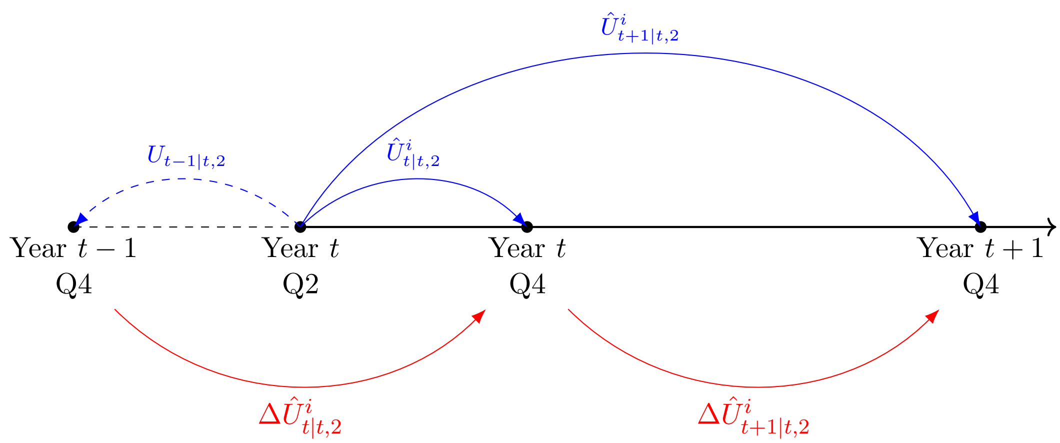


Note: This figure illustrates the calculation of annual changes in the unemployment rate based on the projections released at Q2 by policymaker i. The blue lines describe the projections published at Q2 of the year, the blue dotted line shows the real-time data of the level at the previous year, and the red lines describe the computed annual changes.

Figure 1: Illustration of Computing Annual Changes

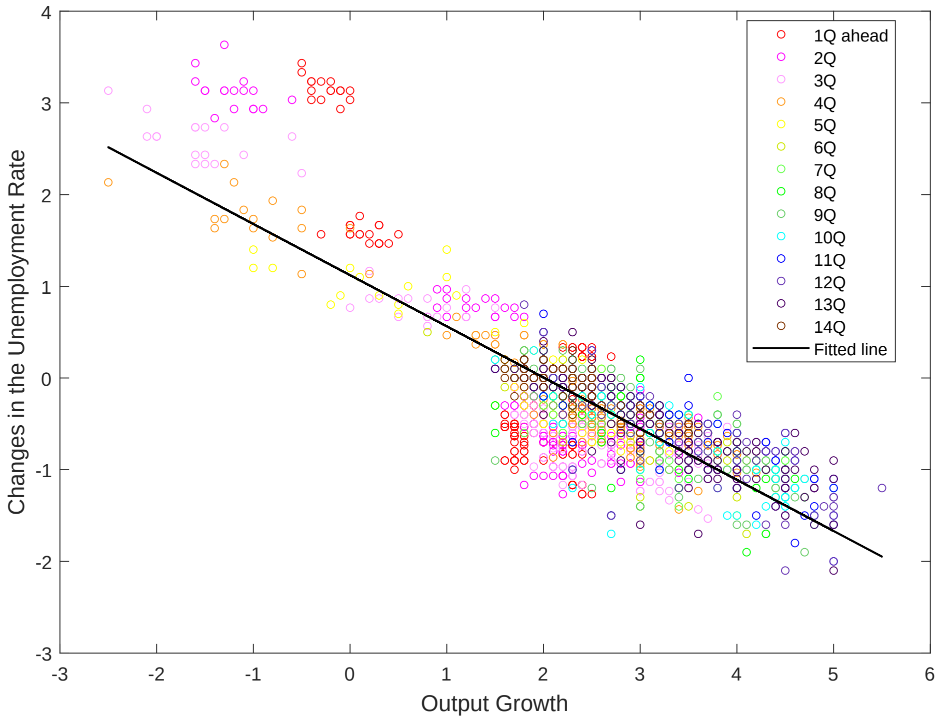
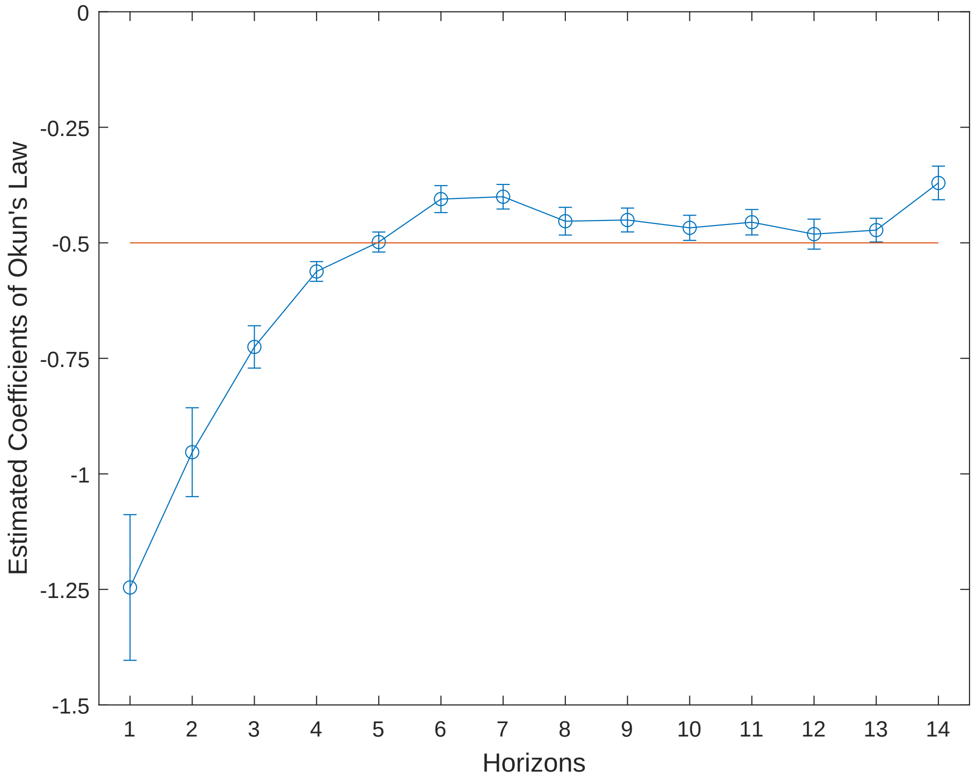


Figure 2: The FOMC's Output Growth and Unemployment Projections



Note: This figure shows the estimated slope of Okun's law using the samples of individual horizons. The estimates are shown in the circle with the bands of standard deviation based on HAC standard errors.

Figure 3: Estimated Slope of Okun's Law at Individual Horizons

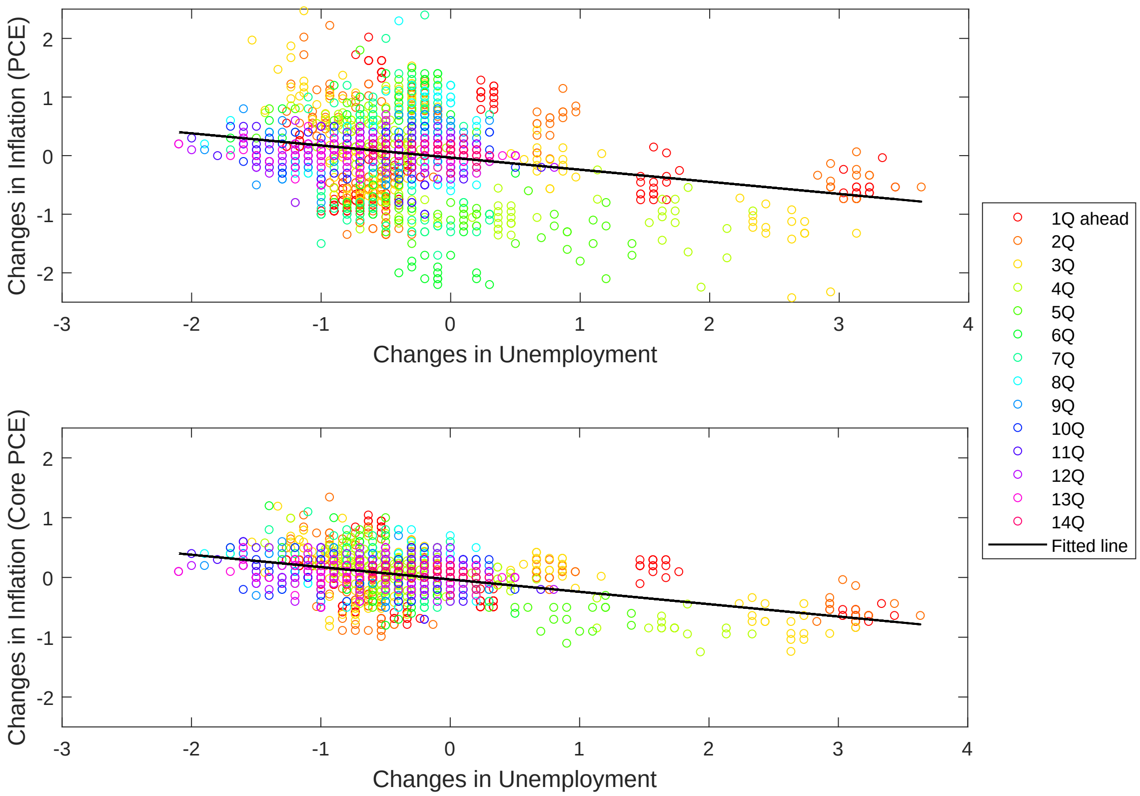
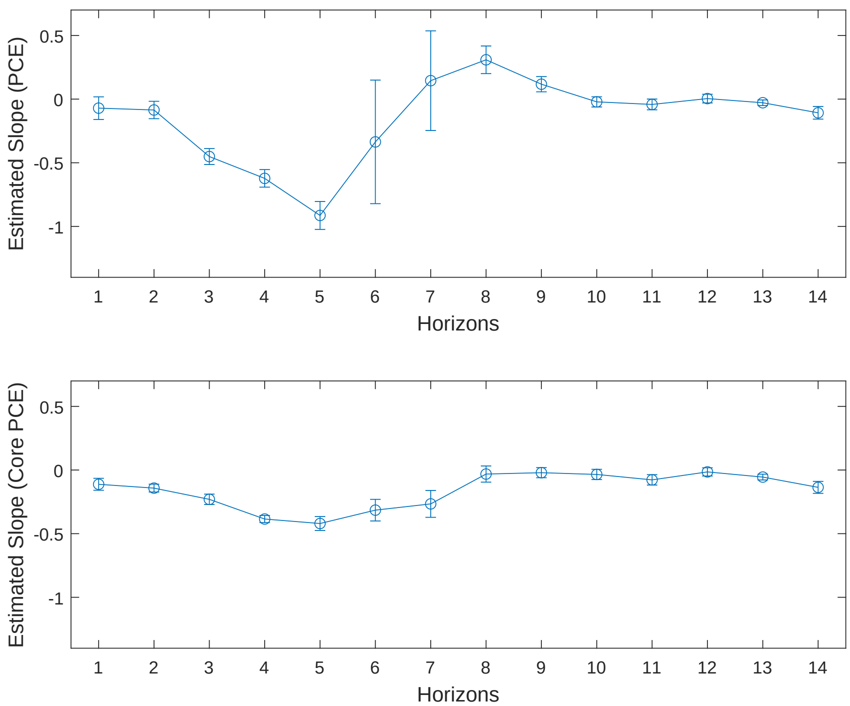


Figure 4: The FOMC's Inflation and Unemployment Projections (PCE and Core PCE)



Note: This figure shows the estimated slope of the Phillips curve based on PCE and Core PCE using the samples of individual horizons. The estimates are shown in the circle with the bands of standard deviation based on HAC standard errors.

Figure 5: Estimated Coefficients of the Phillips Curve at Quarterly Horizons

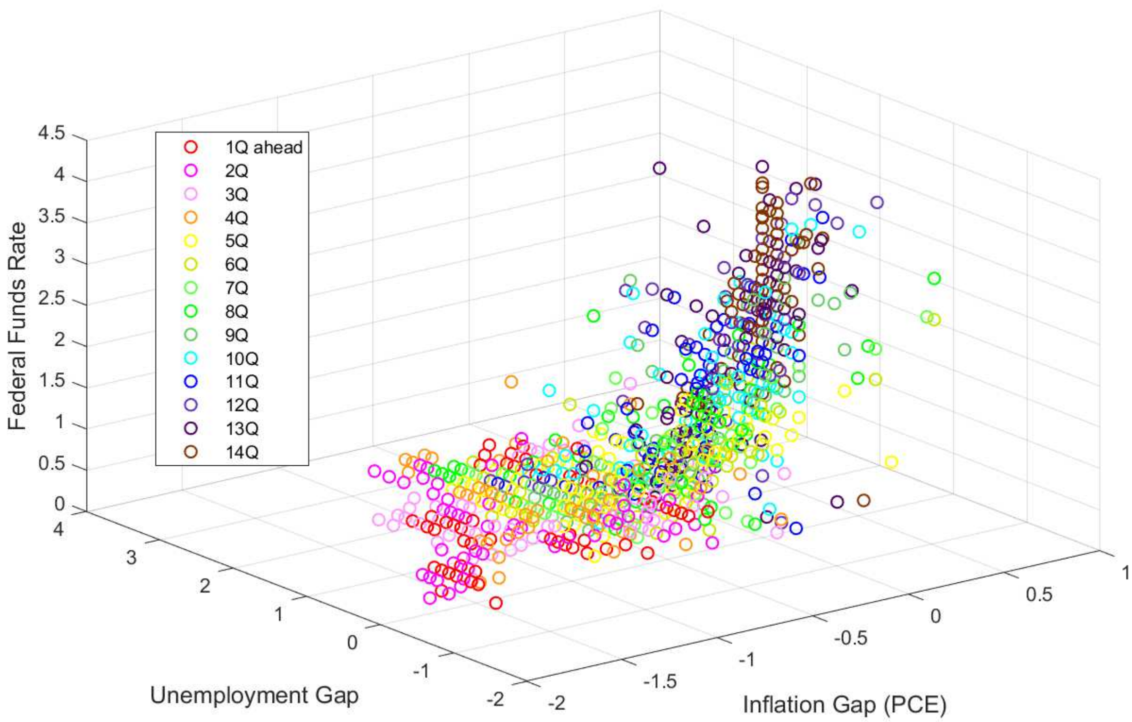
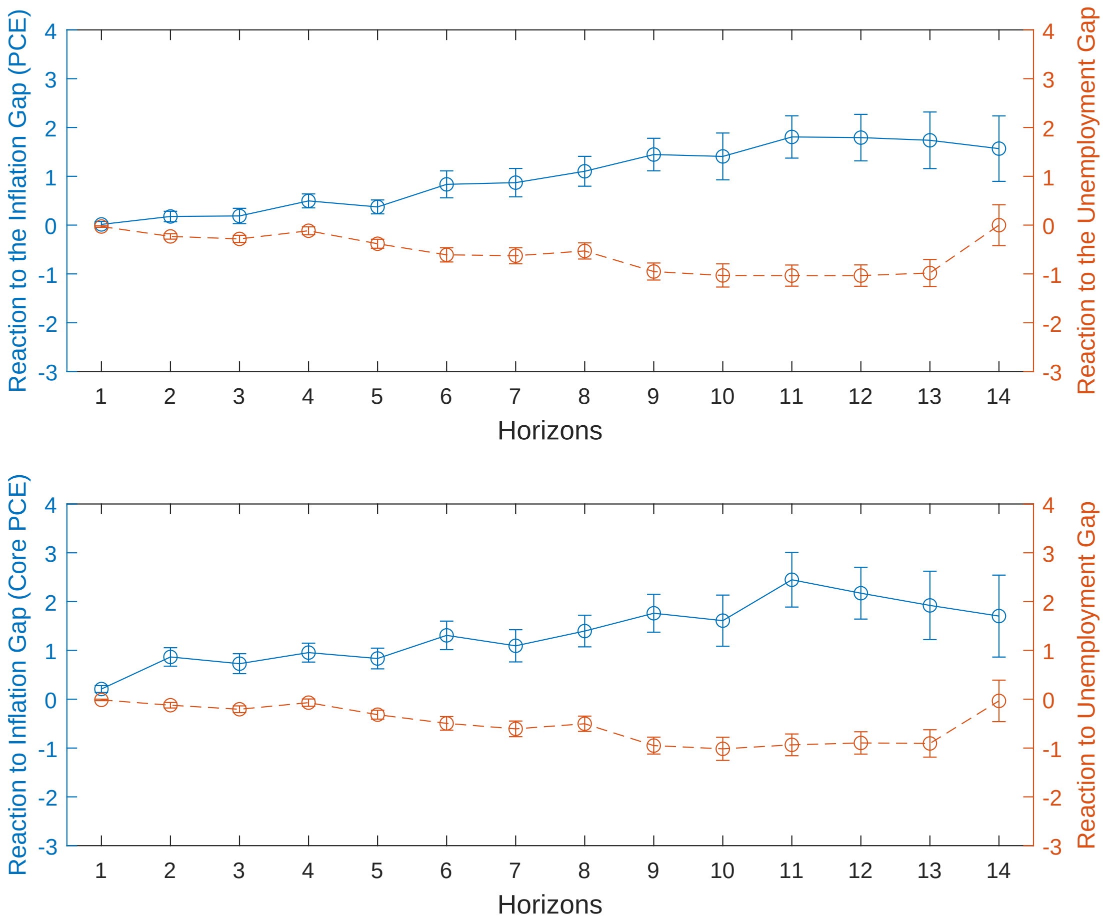
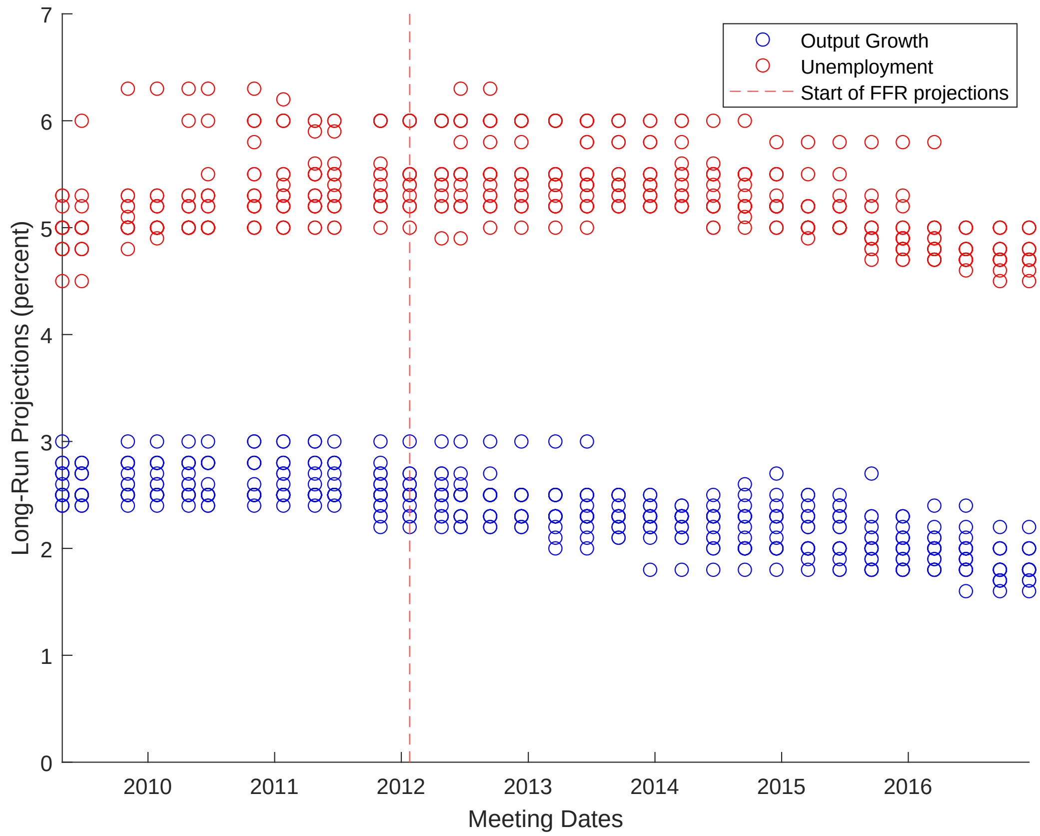


Figure 6: The FOMC's Projections for the Unemployment Gap, Inflation Gap (PCE), and Federal Funds Rates



Note: This figure shows the estimated responses to the inflation gap (blue solid line) and the unemployment gap (red dotted line) using the samples of individual horizons. The estimates are shown in the circle with the bands of standard deviation based on HAC standard errors.

Figure 7: Reactions to the Inflation and Unemployment Gaps at Individual Horizons



Note: This figure shows the individual projections of FOMC policymakers for output growth and unemployment over the longer run. The starting date of the projections for the federal funds rate (FFR) is denoted by the dotted line.

Figure 8: The FOMC's Individual Projections over the Longer Run

	(1)	(2)	(3)
Constant	1.12***	1.41***	1.03***
Slope	−0.56***	−0.55***	−0.63***
Fixed effects:			
Meetings		Yes	
Horizons			Yes
Wald statistics	1124.53***	4550.56***	1826.86***
Adjusted R^2	0.68	0.73	0.72
Observations	2225	2225	2225

[a.] This table shows the results of regressions testing Okun's law with different specifications.
[b.] Inference is based on heteroscedasticity and autocorrelation robust (HAC) standard errors. *** denotes the significance level at 1%.

Table 1: Estimates of Okun's Law (FOMC's Projections)

	PCE			Core PCE		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	-0.03	-0.02	-0.07	-0.01	-0.12^{**}	-0.06
Slope	-0.21^{***}	-0.21^{***}	-0.20^{***}	-0.17^{***}	-0.16^{***}	-0.17^{***}
Fixed effects						
Meetings		Yes			Yes	
Horizons			Yes			Yes
Wald statistics	21.80^{***}	442.33^{***}	52.94^{***}	68.93^{***}	1251.01^{***}	111.94^{***}
Adjusted R^2	0.06	0.22	0.07	0.18	0.30	0.17
Observations	2225	2225	2225	2225	2225	2225

[a.] This table shows the results of regressions testing the Phillips curve with two measures of inflation (PCE and Core PCE) and different specifications.
[b.] Inference is based on HAC standard errors. ** and *** denote the significance level at 5% and 1%, respectively.

Table 2: Estimates of the Phillips Curve (FOMC's Projections)

	PCE			Core PCE		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	2.18***	1.93***	2.97***	2.23***	2.03***	2.98***
Responses to:						
Unemployment Gap	−0.70***	−0.63***	−0.58***	−0.63***	−0.41***	−0.54***
Inflation Gap	1.35***	1.52***	0.82***	2.24***	2.73***	1.30***
Fixed effects						
Meetings		Yes			Yes	
Horizons			Yes			Yes
Log Likelihood	−274.87	−204.92	−93.57	−266.22	−197.72	−89.12
Observations	1258	1258	1258	1258	1258	1258

[a.] This table shows the results of regressions estimating the reaction function with two measures of the inflation gap (PCE and Core PCE) and different specifications.
[b.] Inference is based on HAC standard errors. *** denotes the significance level at 1%.

Table 3: Estimates of the Reaction Function

	(1)	(2)	(3)
Constant	1.11^{***}	1.24^{***}	0.99^{***}
Slope	-0.56^{***}	-0.48^{***}	-0.60^{***}
Fixed effects			
Meetings		Yes	
Horizons			Yes
Wald statistics	368.26^{***}	3058.41^{***}	508.87^{***}
Adjusted R^2	0.60	0.68	0.62
Observations	4528	4528	4528

[a.] This table shows the results of regressions testing Okun's law with different specifications.
[b.] Inference is based on HAC standard errors. *** denotes the significance level at 1%.

Table 4: Estimates of Okun's Law (SPF Forecasts)

	PCE			Core PCE		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	0.07*	0.17	0.07	0.06***	−0.14	−0.04
Slope	−0.32***	−0.37***	−0.32***	−0.24***	−0.26***	−0.23***
Fixed effects						
Meetings		Yes			Yes	
Horizons			Yes			Yes
Wald statistics	79.98***	637.66***	241.29***	387.76***	936.71***	664.67***
Adjusted R^2	0.13	0.24	0.14	0.25	0.30	0.27
Observations	3338	3338	3338	3344	3344	3344

[a.] This table shows the results of regressions testing the Phillips curve with different specifications.
[b.] Inference is based on HAC standard errors. * and *** denote the significance level at 10% and 1%, respectively.

Table 5: Estimates of the Phillips Curve (SPF Forecasts)

	PCE			Core PCE		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	2.00***	2.16***	3.18***	2.18***	2.23***	3.20***
Responses to						
Output Gap	−0.45***	−0.20**	−1.00***	−0.45***	−0.30***	−0.96***
Inflation Gap	1.69***	1.99***	0.33**	3.05***	3.43***	1.13***
Fixed effects						
Meetings		Yes			Yes	
Horizons			Yes			Yes
Log Likelihood	−622.89	−288.61	−256.75	−539.42	−211.25	−215.86
Observations	1258	1258	1258	1258	1258	1258

a. This table shows the results of regressions estimating the reaction function with two measures of the inflation gap (PCE and Core PCE) and different specifications.

b. Inference is based on HAC standard errors. ** and *** denote the significance level at 5% and 1%, respectively.

Table 6: Estimates of the Reaction Function Based on the Output Gap