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

Natsuki Arai†

September 20, 2022

*I am grateful to Larry Ball, Ippei Fujiwara, Yasuo Hirose, Hibiki Ichiue, Sophocles Mavroeidis, Yoshiyuki Nakazono, Rodrigo Sekkel, Tara Sinclair, Jonathan Wright, Yohei Yamamoto, and the participants of the seminars at George Washington University, Johns Hopkins University, Keio University, National Chengchi University, and Yokohama City University, and the participants at Hitotsubashi Institute for Advanced Study, Macroeconometric Modeling Workshop 2020, CEF 2021 for their helpful comments. I thank Shian Chang for excellent research assistance. I gratefully acknowledge the financial support of the Taiwanese Ministry of Science and Technology's grants 108-2410-H-004-009 and 110-2410-H-004-183. All errors are the sole responsibility of the author.

†Department of International Business, National Chengchi University. Address: No. 64, Sec. 2, Tz-nan Rd., Wenshan, Taipei 11605, Taiwan. E-mail: narai@nccu.edu.tw.

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

J.E.L. codes: C53, E43, E47, E58

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. By exploiting the cross-sectional variation of individual projections, this paper provides more efficient estimates than those using the time-series variation of aggregate projections.

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 four extensions to the main results. First, I analyze the consistency of the

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

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 are likely driven by the sample period rather than by the factors specific to the forecasters. Second, I conduct the same analysis using the aggregate SEP using the sample between 2007 and 2022, finding largely similar results. Third, I offer estimates based on the quantile regression to shed some light on the dispersion of estimates across quantiles. Last, 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

[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).

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 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.

[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.

[6] For recent discussions, see Bodilsen et al. (2021), Couture (2021), Du et al. (2018), and Indriawan et al. (2021).

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 (FFR) 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 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 projections from 2007 to 2016 are currently available. These individual projections are anonymous, and 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. The participants' keys that map these numbers and the identities of policymakers are released 5 or 10 years after a meeting.[9] As a result, individual projections with policymakers' identities are partially available from 2007 to 2011 and for 2016 at the time of writing.[10]

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

[7] The projections over the longer run were added in 2009.

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

[9] The embargo period was initially 10 years and the FOMC changed it to 5 years in 2016.

[10] Appendix Table A1 provides the summary statistics of the projections with identities, listing the mean of projections across all forecast horizons and the corresponding standard deviation. These statistics suggest that variations between policymakers are substantial, especially for projections of the federal funds rate.

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, $\Delta \hat{U}^i_{t+1|t,2} = \hat{U}^i_{t+1|t,2} - \hat{U}^i_{t|t,2}$. 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.[11]

It is straightforward to test whether the FOMC individual policymaker's projections are con-

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

sistent 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,[12] 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 and FOMC policymakers largely agree with these facts and theories.[13] 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

[12] 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.

[13] 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.

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:

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

where π, U^n, and v denote the rate of inflation, the natural rate of unemployment, and the supply shock, respectively.[14] 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,

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

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 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:[15]

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

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. This specification does not include the past interest rate, although it is a common term to include in the Taylor rule to represent inertia in the interest rate. This is because I cannot track the individual participants' projections across meetings.

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:

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

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 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).[16] The likelihood for a given forecast horizon h and quarter q is written as follows:

[15] For example, see Chapter 3 of Galí (2015). The results based on the output gap are discussed in Section 4.4.

[16] 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.

$$L_{h,q} = \prod_{i=1}^{N} \prod_{t \in T_{h,q}^{i,0}} \left(1 - \Phi \left[\frac{\rho_{h,q} + \phi_{h,q}^{\pi}(\hat{\pi}_{t+h|t,q}^{i} - \hat{\pi}_{LR|t,q}^{i}) - \phi_{h,q}^{U}(\hat{U}_{t+h|t,q}^{i} - \hat{U}_{LR|t,q}^{i})}{\sigma} \right] \right)$$
$$\times \prod_{i=1}^{N} \prod_{t \notin T_{h,q}^{i,0}} \left(\frac{1}{\sigma} \varphi \left[\frac{\hat{i}_{t+h|t,q}^{i} - \rho_{h,q} + \phi_{h,q}^{\pi}(\hat{\pi}_{t+h|t,q}^{i} - \hat{\pi}_{LR|t,q}^{i}) - \phi_{h,q}^{U}(\hat{U}_{t+h|t,q}^{i} - \hat{U}_{LR|t,q}^{i})}{\sigma} \right] \right), \quad (11)$$

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

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

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.

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.

To interpret this difference in the estimated coefficients across forecast horizons, Figure 4 shows the output growth and the changes in unemployment projections at different forecast horizons. The figure suggests that the projections made during the Great Recession between 2008 and 2009 contribute to the steeper estimated slopes at the shorter horizons.[17] This result likely reflects the information advantage on short-term forecasts and policymakers' views on the persistence of a current economic shock, as documented in the literature.[18] On the one hand, FOMC policymakers primarily use information about a current economic shock, which is partially available in real time, to formulate their nowcasts and short-run forecasts. On the other hand, they rely on macroeconomic principles in the medium to long term once the effects of a current economic shock starts to fade away.

3.2 The Phillips Curve

Figure 5 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

[17] Appendix Table A2 shows the pooled estimates excluding the Great Recession (from December 2007 to June 2009 following NBER). The results are generally similar to the results obtained using the whole sample.

[18] For details, see Faust and Wright (2013) and Wright (2019).

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 6 shows the estimated slopes of the Phillips curve at each quarterly horizon, as described in Equation (6), with the corresponding standard errors. Similar to the results of Okun's law, the figure displays substantial variation in the estimates across horizons. 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.

To interpret this result, Figure 7 depicts the changes in inflation and unemployment rates across different forecast horizons. The figure suggests that 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.[19] 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 medium-term horizons, a sharp fall or rise in inflation did not occur as anticipated.[20] As the target period approaches, FOMC policymakers modify their inflation projections accordingly, which makes the slope suggested by the short-term projections smaller.

[19] Appendix Table A3 shows the pooled estimates excluding the Great Recession, which leads to results similar to those using the whole sample.

[20] 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).

3.3 Reaction Function

Figure 8 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 at longer horizons, although it has been stuck at zero in the short term. Table 3 presents the average partial effect of the Tobit regression.[21] The results show that the estimated effect of the constant, which may be interpreted as the equilibrium real interest rate, are positive, and their magnitude is between 1.86 and 2.91. The estimated responses to the unemployment gap are significantly negative in all cases, ranging from -0.67 to -0.40, while the estimated responses to the inflation gap are significantly positive at between 0.80 and 2.63. 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.[22]

Figure 9 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.

[21] Corresponding estimates based on the linear model are listed in Appendix Table A4, which shows that the estimated effects are broadly similar to those of the Tobit model. This is likely because expectations are less subject to the ELB.

[22] For details, see Galí (2015).

4 Extensions

4.1 Comparison with the SPF forecasts

As an extension, I conduct 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 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. Finally, the economic models that the FOMC's policymakers and the SPF forecasters use may differ, as discussed in Binder (2021).

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 0.91 and 1.17, and the estimated slopes are between −0.61 and −0.45. Adjusted R^2 are relatively high, and approximately 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 −0.35 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 0.25 for PCE inflation and 0.25 and 0.35 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.[23]

To shed light on how individual forecasters act differently in following these macroeconomics

[23] 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).

principles, the tables also list the results after controlling for the individual fixed effects and their interaction terms with the slope. The estimated coefficients for both Okun's law and the Phillips curve are largely similar, suggesting that individual differences across forecasters would not materially affect the main results. In addition, the table lists the proportion of forecasters whose controls are significantly rejected at the 5% level. The results suggest that only a moderate fraction of forecasters have a significantly different tendency from the common principles. The only exception is the slope of the Phillips curve using core PCE, in which nearly 70% of the forecasters have significantly different slopes from the common principle. However, this is likely due to the positive estimate of the slope of the Phillips curve. Overall, these results confirm that heterogeneity across forecasters has only a modest quantitative effect on the pooled estimates, and cross-sectional variation is useful to identify the common coefficients.

4.2 Comparison with the Aggregate SEP

I also conduct the same analysis using the FOMC's aggregate SEP. Since the SEP is released immediately after meetings, we have a longer sample available from 2007 to 2022, although the sample size is substantially smaller without cross-sectional variation. The SEP is released in the form of ranges, and I use the midpoint of the central tendency for the analysis, which excludes the three lowest and highest values of the projections from the ranges.[24]

Tables 6 and 7 show the estimates of Okun's law and the Phillips curve.[25] The results are generally similar to those obtained using the FOMC's individual projections. For Okun's law, the estimates of the constants are between 1.17 and 1.30, and the estimated slopes are between −0.65 and −0.63, which is consistent with the conventional values. Adjusted R^2 are high, and nearly 90% of the variations are explained by the regression. On the other hand, the Phillips curve relationship is much weaker, with the estimated slopes between −0.28 and −0.18 with insignificant constants. Although the null hypothesis that all the coefficients are zero is strongly rejected, the adjusted R^2 is extremely low.

[24] The analysis using other summary statistics, such as lowest or highest values or those for ranges, leads to quantitatively similar results.

[25] Due to the small sample size, I only report the pooled estimates with horizon and meeting fixed effects.

4.3 Quantile Regression

To shed light on the heterogeneity across quantiles, I conduct the estimation based on a quantile regression, which estimates the τth quantile of the dependent variable conditional on the independent variables, instead of a conventional regression that estimates the average effects.[26] Figure 10 shows a summary of quantile regression estimates based on the linear model of Okun's law, the Phillips curve, and the reaction function. Due to a relatively small sample, I use the linear models without fixed effects as a benchmark and present the estimates for τ, ranging from 0.2 to 0.8.

The figure suggests that a substantial degree of heterogeneity across quantiles exists, although none of them significantly change the signs. For example, the estimated slope of Okun's law ranges between -0.35 and -0.6, while its corresponding OLS estimate is -0.56. For the Phillips curve, there is not much heterogeneity in the slope, perhaps because the explanatory power of regression is small. For the reaction function, the disparity in the constant is substantial, ranging between 1.2 and 3.0. However, the disparity in the responses of the unemployment and inflation gaps is not as large as those of the constant. The estimated response to inflation is less than one for lower quantiles, which contradicts the Taylor principle.

Although the results display a substantial degree of heterogeneity across quantiles, we should be careful about interpretation. Since the model does not control for any fixed effects, observed heterogeneity could be caused by various factors, including news at a specific FOMC meeting, a tendency in forecasting for certain horizons, and the different attitudes of policymakers. The estimates provide the combined effects of these various factors.

4.4 Estimation of the Reaction Function Based on the Output Gap

Table 8 presents the average partial effect of the Tobit regression using the output gap. The results are different from the results based on the unemployment gap in two ways. First, the estimated effect 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

[26] For details, see Koenker and Hallock (2001).

constant ranges from 1.81 to 3.08, and the estimated response to the inflation gap ranges from 0.32 to 3.31.

These different estimates likely reflect the changes in output growth projections in the longer run. As indicated in Figure 11, 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 estimates of the FOMC's reaction function, which are consistent with a conventional Taylor rule.

Overall, 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. Understanding the FOMC's forecasting principle is crucial for the efficacy of monetary policy, especially at the ELB, where communication on future monetary policy plays an important role.

This paper offers two innovations by exploiting the cross-sectional variations of the FOMC's individual projections. First, it provides more efficient estimates of the FOMC's macroeconomic principles, especially for the reaction function, even when the sample period is relatively short. Second, this paper highlights that FOMC policymakers' forecasting behaviors differ across the forecast horizons—they tend to follow macroeconomic principles for relatively longer horizons, while there are some deviations in the short run. None of these innovations is feasible without cross-sectional variations.

This paper demonstrates that the FOMC's individual projections provide researchers with substantially richer variations. Once the FOMC policymakers' identities become public, researchers will be able to analyze the relationship between their individual projections, individual characteristics, and voting behaviors.[27] Further research on the FOMC's collective decision making would enhance the understanding of their conduct of US monetary policy, which I will leave for a future exercise.

[27] Recent studies provide an interpretation of observed heterogeneity among FOMC participants in terms of their projections and votes. For example, Schultefrankenfeld (2020) analyzed how dissenting views on appropriate monetary policy result in forecast disagreement, and Malmendier et al. (2021) claimed that FOMC participants' own inflation experiences affect their attitude toward inflation.

References

Amemiya, Takeshi, "Tobit Models: A Survey," *Journal of Econometrics*, 1984, *24* (1), 3–61.

Arai, Natsuki, "Evaluating the Efficiency of the FOMC's New Economic Projections," *Journal of Money, Credit and Banking*, 2016, *48* (5), 1019–1049.

Ball, Laurence and Sandeep Mazumder, "Inflation Dynamics and the Great Recession," *Brookings Papers on Economic Activity*, 2011, *42* (1), 337–405.

_ , Joao Tovar Jalles, and Prakash Loungani, "Do Forecasters Believe in Okun's Law? An Assessment of Unemployment and Output Forecasts," *International Journal of Forecasting*, 2015, *31* (1), 176–184.

Belongia, Michael T. and Peter N. Ireland, "Rules versus Discretion: Inference Gleaned from Greenbook Forecasts and FOMC Decisions," Working Paper, 2019.

Bernanke, Ben S., "Federal Reserve Economic Projections: What Are They Good For?," Ben Bernanke's Blog, November 2016.

Bespalova, Olga, "GDP Forecasts: Informational Asymmetry of the SPF and FOMC Minutes," *International Journal of Forecasting*, 2020, *36* (4), 1531–1540.

Binder, Carola, "Central Bank Communication and Disagreement about the Natural Rate Hypothesis," *International Journal of Central Banking*, June 2021, *17* (2), 81–123.

Bodilsen, Simon, Jonas N. Eriksen, and Niels S. Grønborg, "Asset Pricing and FOMC Press Conferences," *Journal of Banking & Finance*, 2021, *128*, 106–163.

Bundick, Brent, "Estimating the Monetary Policy Rule Perceived by Forecasters," *Economic Review*, 2015, (Q IV), 33–49.

Carvalho, Carlos and Fernanda Nechio, "Do People Understand Monetary Policy?," *Journal of Monetary Economics*, 2014, *66*, 108–123.

Casey, Eddie, "Do Macroeconomic Forecasters Use Macroeconomics to Forecast?," *International Journal of Forecasting*, 2020, *36* (4), 1439–1453.

Christiano, Lawrence J., Martin S. Eichenbaum, and Mathias Trabandt, "Understanding the Great Recession," *American Economic Journal: Macroeconomics*, January 2015, *7* (1), 110–67.

Coibion, Olivier and Yuriy Gorodnichenko, "Is the Phillips Curve Alive and Well after All? Inflation Expectations and the Missing Disinflation," *American Economic Journal: Macroeconomics*, January 2015, *7* (1), 197–232.

_ , _ , and Mauricio Ulate, "The Cyclical Sensitivity in Estimates of Potential Output," *Brookings Papers on Economic Activity*, Fall 2018, pp. 343–441.

Couture, Cody, "Financial Market Effects of FOMC Projections," *Journal of Macroeconomics*, 2021, *67*, 103279.

Del Negro, Marco, Michele Lenza, Giorgio E. Primiceri, and Andrea Tambalotti, "What's up with the Phillips Curve?," Working Paper 27003, National Bureau of Economic Research, April 2020.

Dräger, Lena, Michael J. Lamla, and Damjan Pfajfar, "Are Survey Expectations Theory-Consistent? The Role of Central Bank Communication and News," *European Economic Review*, 2016, *85*, 84–111.

Du, Brian, Scott Fung, and Robert Loveland, "The Informational Role of Options Markets: Evidence from FOMC Announcements," *Journal of Banking & Finance*, 2018, *92*, 237–256.

Ellison, Martin and Thomas J. Sargent, "A Defense of the FOMC," *International Economic Review*, November 2012, *53* (4), 1047–1065.

Faust, Jon and Jonathan H. Wright, "Forecasting Inflation," in G. Elliott, C. Granger, and A. Timmermann, eds., *Handbook of Economic Forecasting*, Vol. 2, Elsevier, 2013, chapter 3, pp. 2–56.

Faust, Jon D., "Oh What a Tangled Web We Weave: Monetary Policy Transparency in Divisive Times," Hutchins Center Working Paper, 2016.

Fendel, Ralf and Jan-Christoph Rülke, "Are heterogeneous FOMC forecasts consistent with the Fed's monetary policy?," *Economics Letters*, 2012, *116* (1), 5–7.

Gagnon, Joseph E. and Christopher G. Collins, "Low Inflation Bends the Phillips Curve," Working Paper, Peterson Institute for International Economics, 2019.

Galí, Jordi, *Monetary Policy, Inflation, and the Business Cycle, 2nd Edition*, Princeton University Press, 2015.

Gamber, Edward N. and Julie K. Smith, "Are the Fed's Inflation Forecasts Still Superior to the Private Sectors?," *Journal of Macroeconomics*, 2009, *31* (2), 240–251.

Gilchrist, Simon, Raphael Schoenle, Jae Sim, and Egon Zakrajšek, "Inflation Dynamics during the Financial Crisis," *American Economic Review*, March 2017, *107* (3), 785–823.

Guisinger, Amy Y. and Tara M. Sinclair, "Okun's Law in Real Time," *International Journal of Forecasting*, 2015, *31* (1), 185–187.

Hooper, Peter, Frederic S. Mishkin, and Amir Sufi, "Prospects for Inflation in a High Pressure Economy: Is the Phillips Curve Dead or Is It Just Hibernating?," *Research in Economics*, 2020, *74* (1), 26–62.

Hubert, Paul, "FOMC Forecasts as a Focal Point for Private Expectations," *Journal of Money, Credit and Banking*, 2014, *46* (7), 1381–1420.

Indriawan, Ivan, Feng Jiao, and Yiuman Tse, "The FOMC Announcement Returns on Long-Term US and German Bond Futures," *Journal of Banking & Finance*, 2021, *123*, 106027.

Jordà, Oscar, Noah Kouchekinia, Colton Merrill, and Tatevik Sekhposyan, "The Fog of Numbers," *FRBSF Economic Letter*, July 2020, *20.*

Jorgensen, Peter Lihn and Kevin J. Lansing, "Anchored Inflation Expectations and the Flatter Phillips Curve," Working Paper, Federal Reserve Bank of San Francisco, 2019.

Jung, Alexander and Sophia Latsos, "Do Federal Reserve Bank Presidents Have a Regional Bias?," *European Journal of Political Economy*, 2015, *40*, 173–183.

Kahn, George A. and Andrew Palmer, "Monetary Policy at the Zero Lower Bound: Revelations from the FOMC's Summary of Economic Projections," *Economic Review*, First Quarter 2016.

Kalfa, S. Yanki and Jaime Marquez, "FOMC Forecasts: Are They Useful for Understanding Monetary Policy?," *Journal of Risk and Financial Management*, 2019, *12* (3), 133.

Kim, Jinil and Seth Pruitt, "Estimating Monetary Policy Rules When Nominal Interest Rates Are Stuck at Zero," *Journal of Money, Credit and Banking*, 2017, *49* (4), 585–602.

Koenker, Roger and Kevin F. Hallock, "Quantile Regression," *Journal of Economic Perspectives*, December 2001, *15* (4), 143–156.

Kuttner, Kenneth and Tim Robinson, "Understanding the Flattening Phillips Curve," *The North American Journal of Economics and Finance*, 2010, *21* (2), 110–125.

Malmendier, Ulrike, Stefan Nagel, and Zhen Yan, "The Making of Hawks and Doves," *Journal of Monetary Economics*, 2021, *117*, 19–42.

Mankiw, Gregory N., *Macroeconomics, 10th edition*, Worth Publisher, 2018.

Matheson, Troy and Emil Stavrev, "The Great Recession and the Inflation Puzzle," *Economics Letters*, 2013, *120* (3), 468–472.

Mavroeidis, Sophocles, "Identification at the Zero Lower Bound," *Econometrica*, 2021, *89* (6), 2855–2885.

Meade, Ellen E. and D. Nathan Sheets, "Regional Influences on FOMC Voting Patterns," *Journal of Money, Credit and Banking*, 2005, *37* (4), 661–677.

Mitchell, Karlyn and Douglas K. Pearce, "Do Wall Street Economists Believe in Okun's Law and the Taylor Rule?," *Journal of Economics and Finance*, April 2010, *34* (2), 196–217.

Morris, Stephen, "Estimating Monetary Policy Rules from Forward Guidance," Working Paper, 2017.

Nakazono, Yoshiyuki, "Strategic Behavior of Federal Open Market Committee Board Members: Evidence from Members' Forecasts," *Journal of Economic Behavior & Organization*, 2013, *93*, 62–70.

Olson, Peter and David Wessel, "Federal Reserve Communications: Survey Results," Hutchins Center, 2016.

Pierdzioch, Christian, Jan-Christoph Rülke, and Georg Stadtmann, "Do Professional Economists' Forecasts Reflect Okun's Law? Some Evidence for the G7 Countries," *Applied Economics*, 2011, *43* (11), 1365–1373.

_ **, Jan-Christoph Rülke, and Peter Tillmann**, "Using Forecasts to Uncover the Loss Function of Federal Open Market Committee Members," *Macroeconomic Dynamics*, 2016, *20* (3), 791–818.

Powell, Tyler and David Wessel, "Federal Reserve Communications: Survey Results," Hutchins Center, 2020.

Romer, Christina D. and David H. Romer, "Federal Reserve Information and the Behavior of Interest Rates," *American Economic Review*, June 2000, *90* (3), 429–457.

Romer, David, "A New Data Set on Monetary Policy: The Economic Forecasts of Individual Members of the FOMC," *Journal of Money, Credit and Banking*, 2010, *42* (5), 951–957.

Schultefrankenfeld, Guido, "Appropriate Monetary Policy and Forecast Disagreement at the FOMC," *Empirical Economics*, 2020, *58*, 223–255.

Sheng, Xuguang (Simon), "Evaluating the Economic Forecasts of FOMC Members," *International Journal of Forecasting*, 2015, *31* (1), 165–175.

Simon, John, Troy Matheson, and Damiano Sandri, "The Dog That Didn't Bark: Has Inflation Been Muzzled or Was It Just Sleeping?," World Economic Outlook, International Monetary Fund, 2013.

Stock, James H. and Mark W. Watson, "Phillips Curve Inflation Forecasts," *Conference Proceedings, Federal Reserve Bank of Boston*, 2008, *53.*

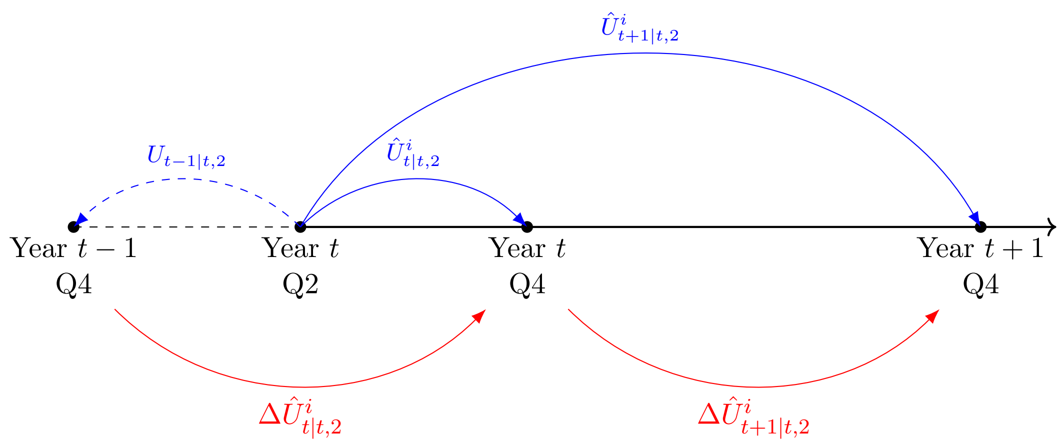
Tillmann, Peter, "The Fed's Perceived Phillips Curve: Evidence from Individual FOMC Forecasts," *Journal of Macroeconomics*, 2010, *32* (4), 1008–1013.

_ , "Strategic Forecasting on the FOMC," *European Journal of Political Economy*, 2011, *27* (3), 547–553.

Verbeek, Marno, *A Guide to Modern Econometrics, 5th Edition*, Wiley, 2017.

Vissing-Jorgensen, Annette, "Central Banking with Many Voices: The Communications Arms Race," *Conference Proceedings, 23rd Annual Conference of the Central Bank of Chile*, 2019.

Wright, Jonathan H., "Some Observations on Forecasting and Policy," *International Journal of Forecasting*, 2019, *35* (3), 1186–1192.



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

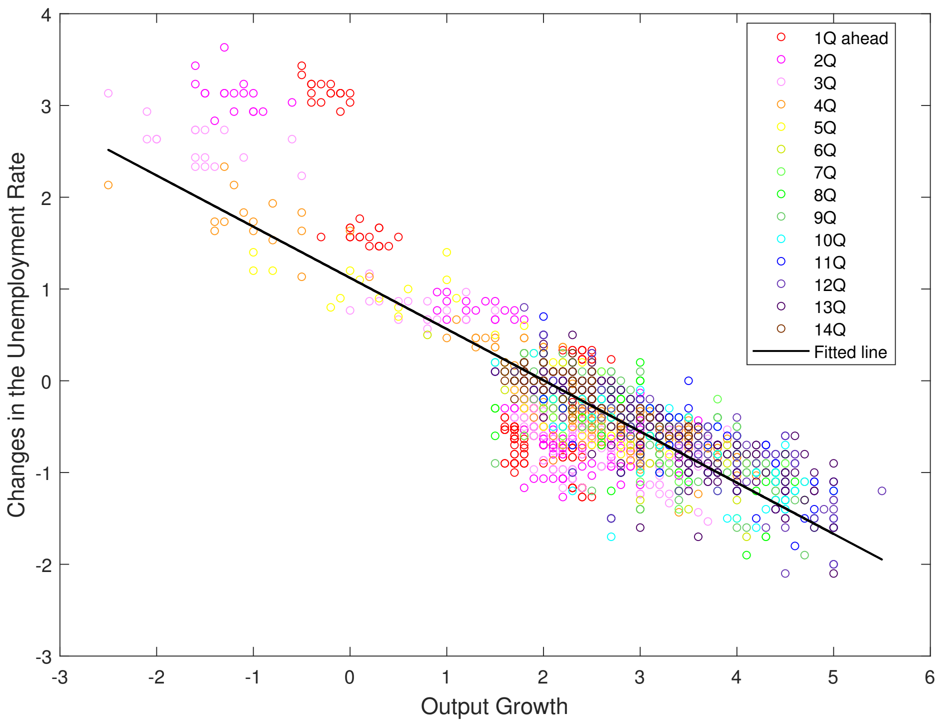
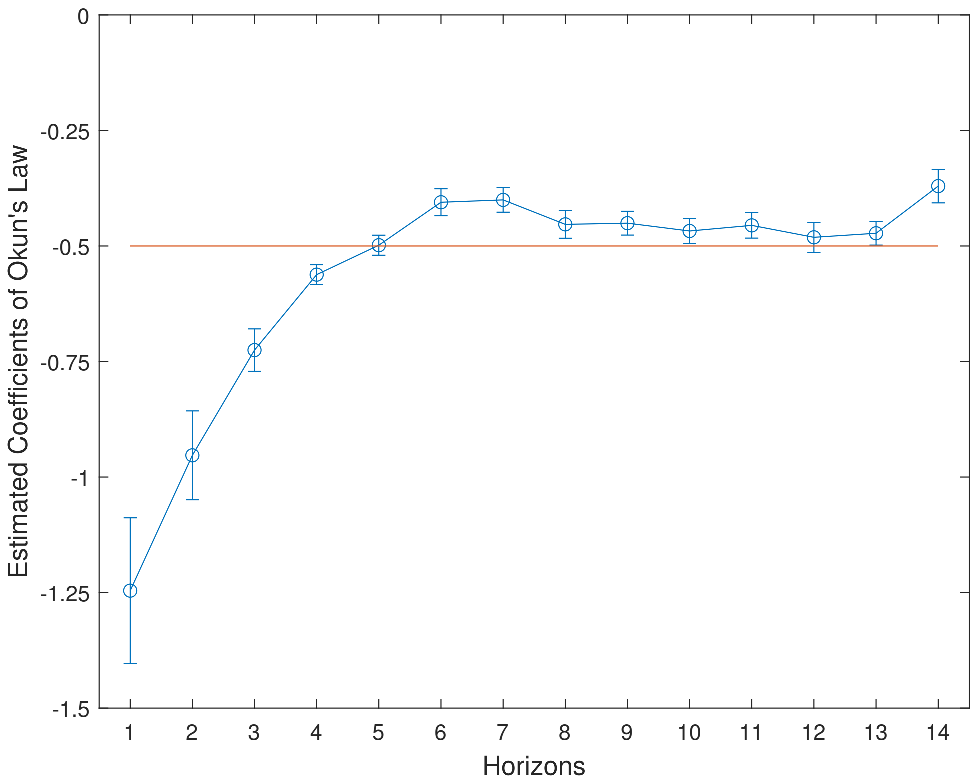
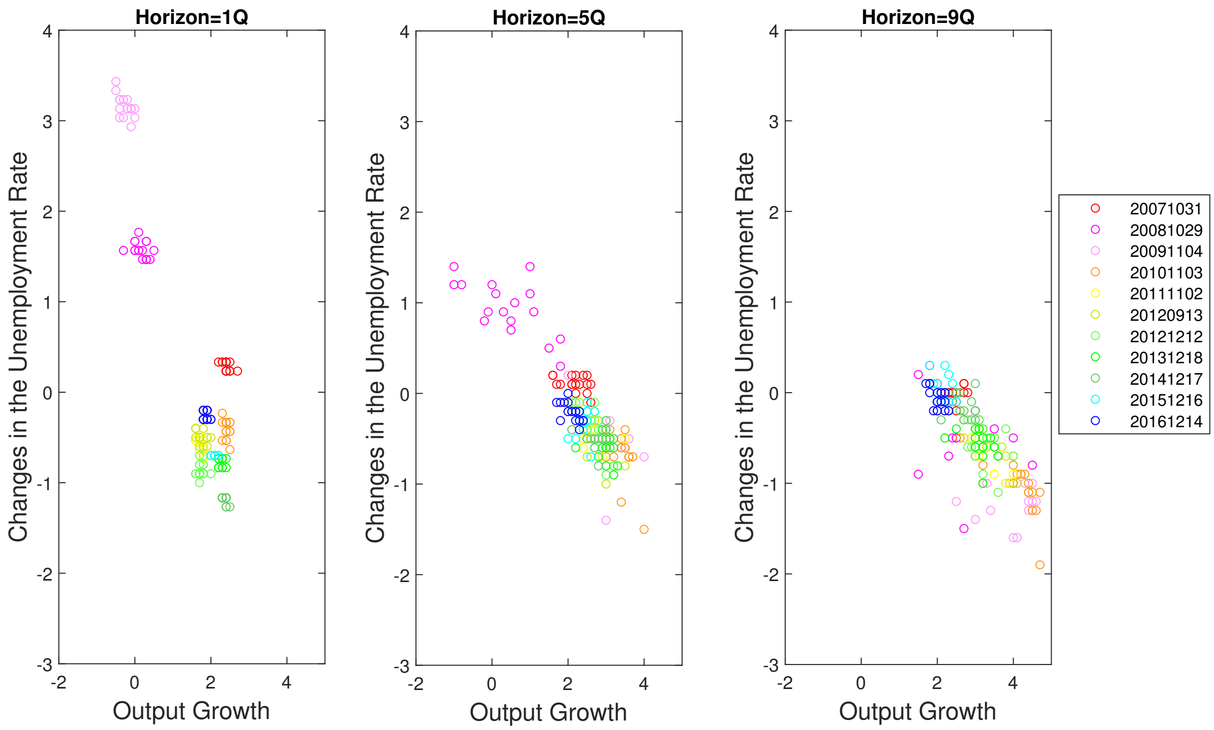


Figure 2: The FOMC's Output Growth and Unemployment Projections



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



Note: This figure shows the plot of output growth and the changes in the unemployment rate at different forecast horizons, with different colors depicting the different meeting days.

Figure 4: The FOMC's Output Growth and Unemployment Projections at Different Forecast Horizons

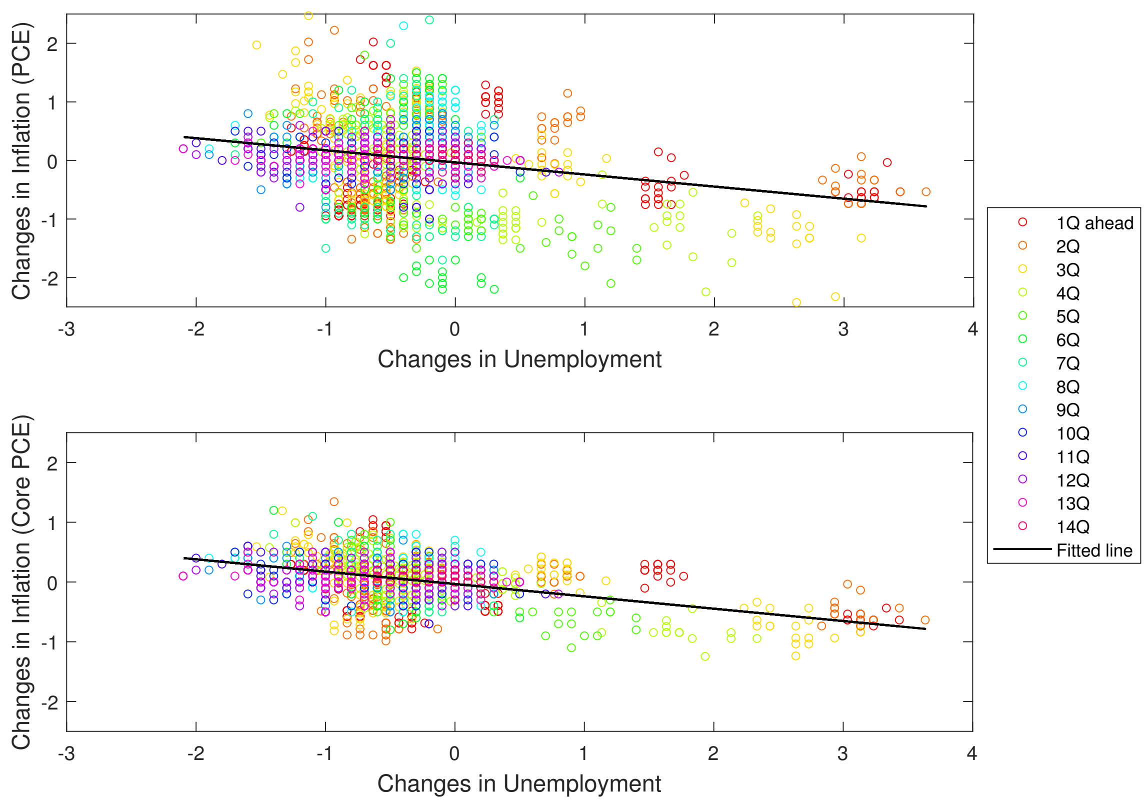
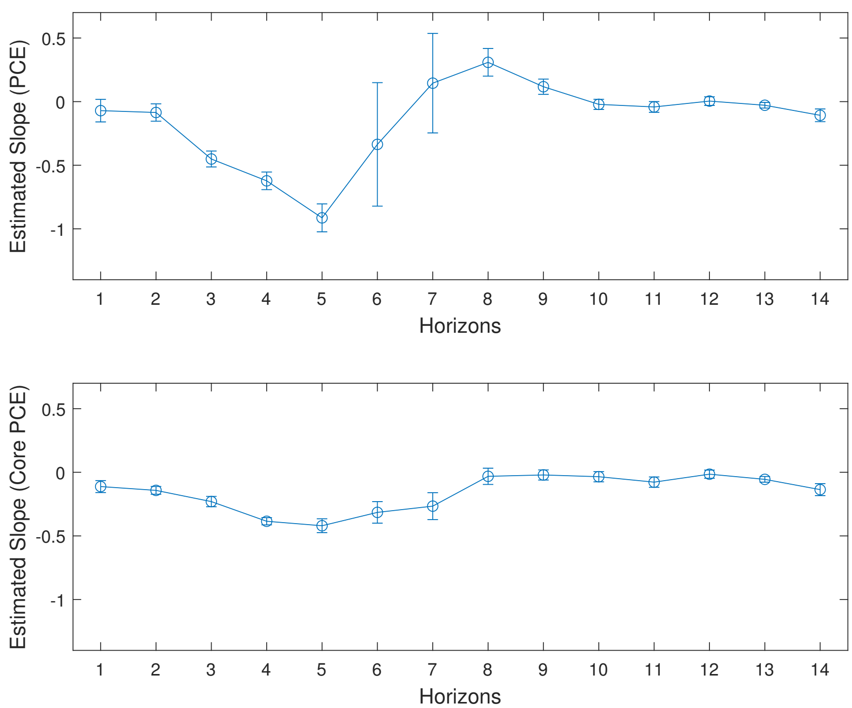
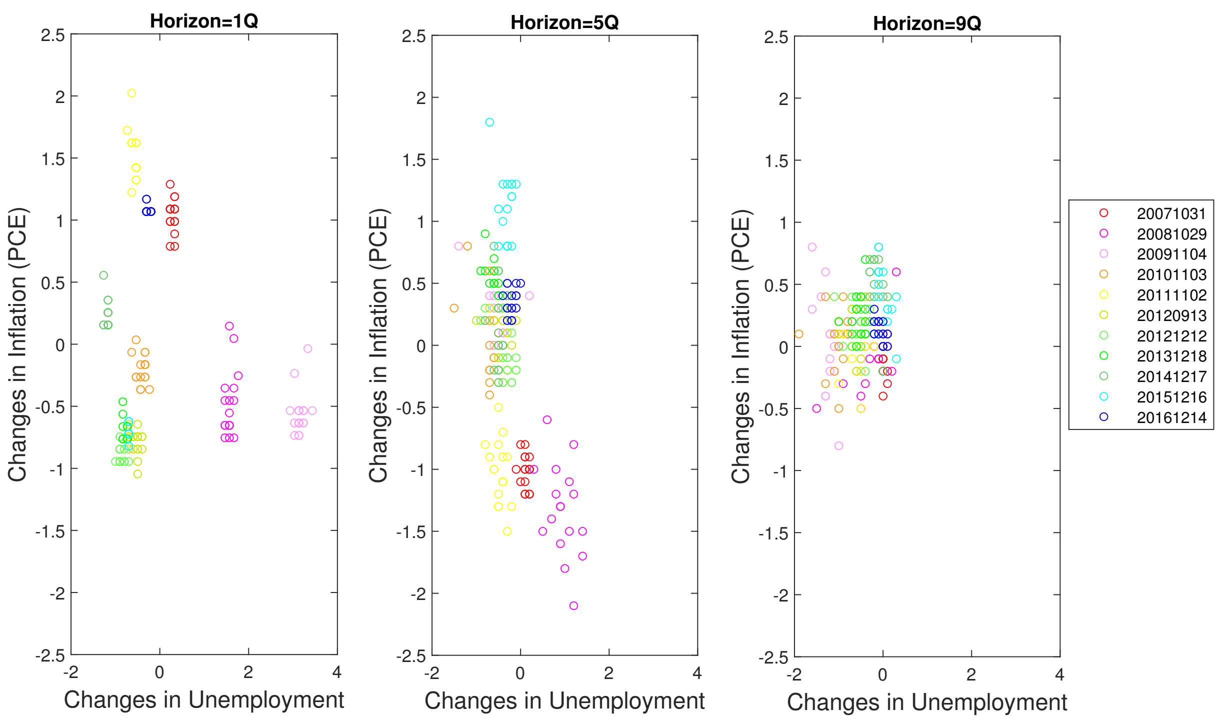


Figure 5: The FOMC's Inflation and Unemployment Projections (PCE and Core PCE)



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 6: Estimated Coefficients of the Phillips Curve at Quarterly Horizons



Note: This figure shows the plot of the changes in PCE inflation and the unemployment rate at different forecast horizons, with different colors depicting the different meeting days.

Figure 7: The FOMC's Inflation and Unemployment Projections at Different Forecast Horizons

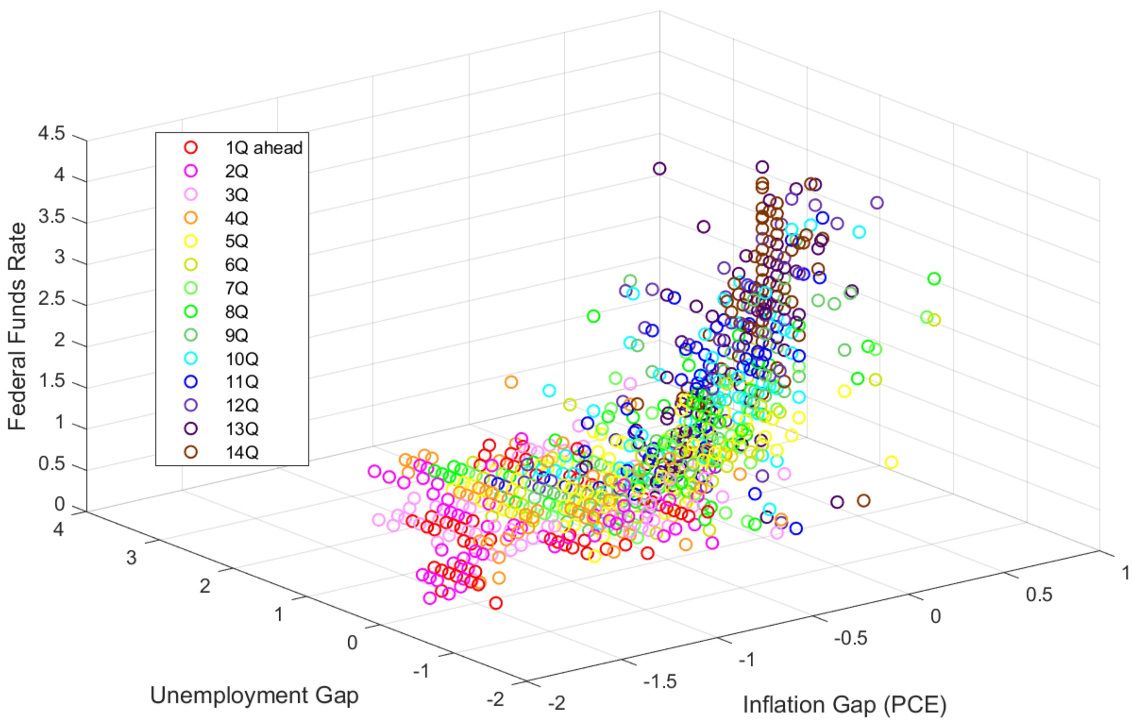
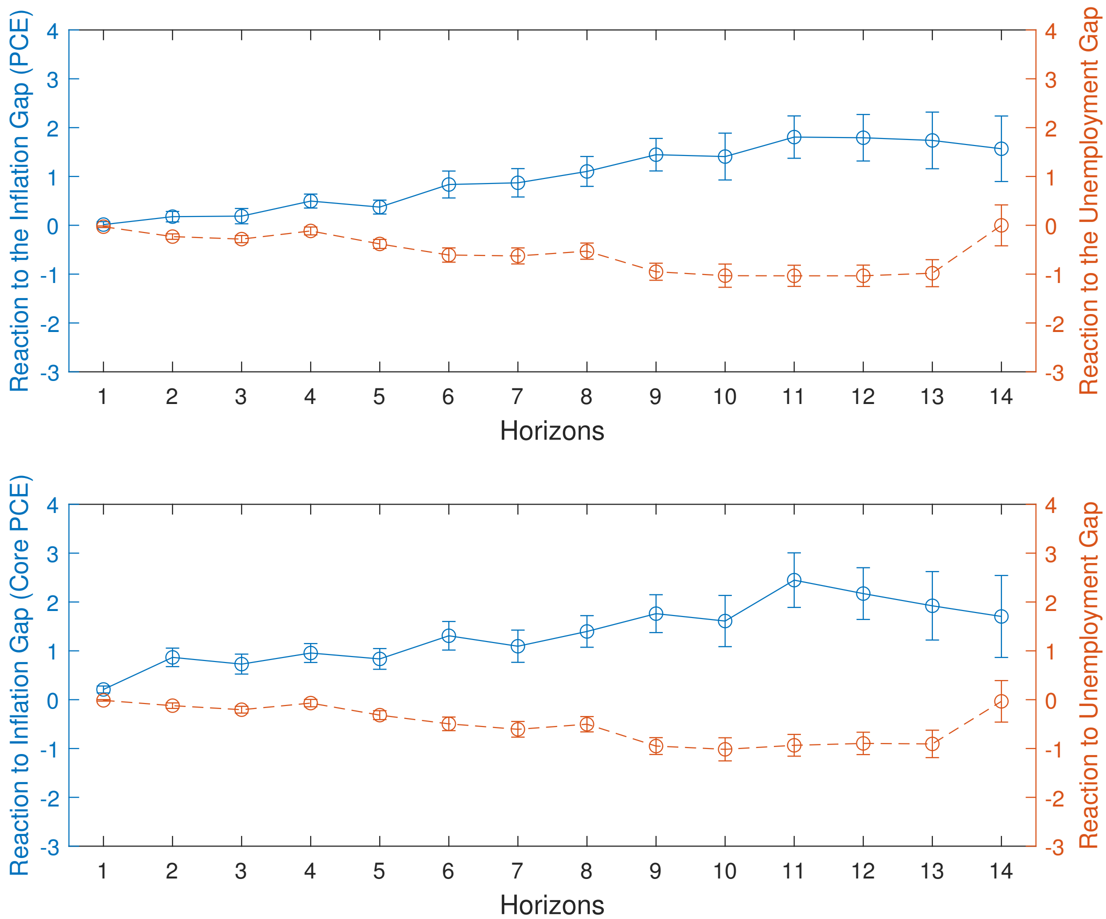
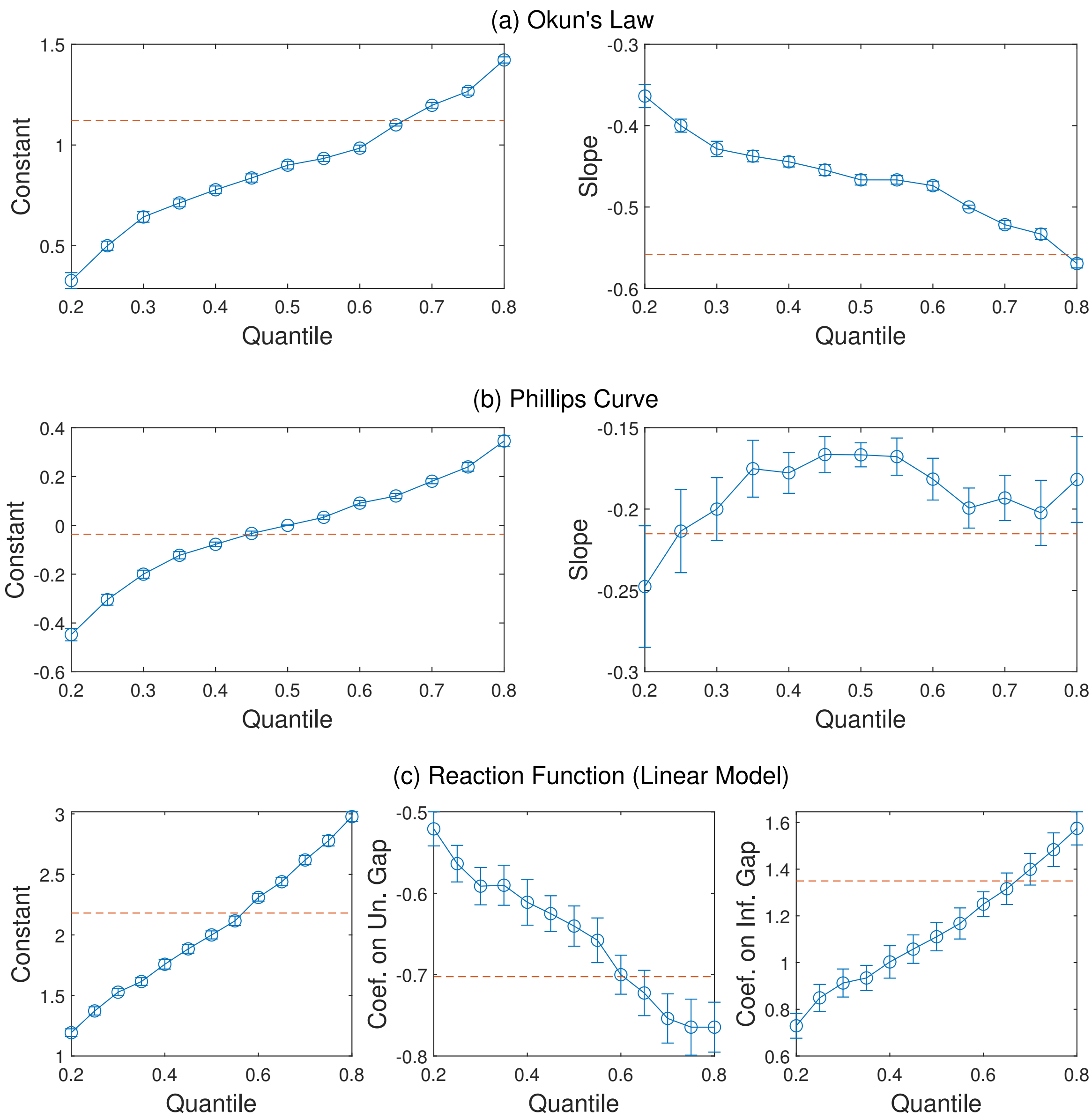


Figure 8: The FOMC's Projections for the Unemployment Gap, Inflation Gap (PCE), and Federal Funds Rates



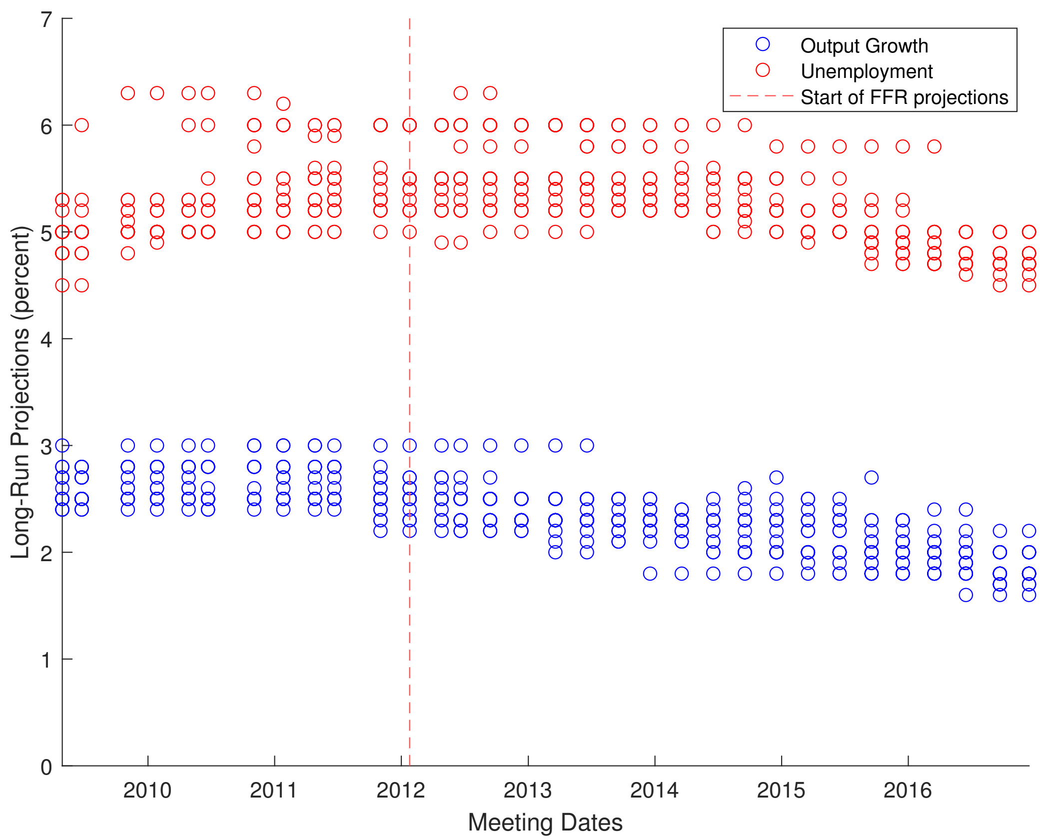
Note: This figure shows the estimated responses to the inflation gap (blue solid line) and the unemployment gap (red dotted line) using the samples of individual horizons. The estimates are shown in the circle with the bands of standard deviation based on HAC standard errors.

Figure 9: Reactions to the Inflation and Unemployment Gaps at Individual Horizons



Note: This figure shows the estimates based on a quantile regression. The corresponding OLS estimates are depicted by the dotted line.

Figure 10: Quantile Regression Estimates of Okun's Law



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 11: 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 Individual 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 Individual Projections)

	PCE			Core PCE		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	2.09^{***}	1.86^{***}	2.90^{***}	2.14^{***}	1.96^{***}	2.91^{***}
Responses to:						
Unemployment Gap	-0.67^{***}	-0.61^{***}	-0.57^{***}	-0.67^{***}	-0.40^{***}	-0.52^{***}
Inflation Gap	1.29^{***}	1.46^{***}	0.80^{***}	2.15^{***}	2.63^{***}	1.27^{***}
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 average partial effect of the Tobit regression 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: Estimated Partial Effect of the Reaction Function (FOMC's Individual Projections)

	(1)	(2)	(3)	(4)	(5)
Constant	1.08***	1.17***	0.95***	1.01***	0.91***
Slope	−0.56***	−0.45***	−0.61***	−0.57***	−0.47***
Controls					
Meetings		Yes			
Horizons			Yes		
Individual				Yes (15.2%)	Yes (42.2%)
Individual ∗ slope					Yes (18.2%)
Wald statistics	368.26***	4990.09***	370.54***	1910.04***	7273.35***
Adjusted R^2	0.58	0.70	0.61	0.63	0.65
Observations	3084	3084	3084	3084	3084

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%.
c. The proportion of forecasters, whose fixed effects are significantly different from zero with the significance level of 5%, is listed in the parenthesis.

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

	(1)	(2)	(3)	(4)	(5)
			Panel A: PCE		
Constant	0.08**	0.16	0.07	0.03	−0.05
Slope	−0.32***	−0.35***	−0.31***	−0.30***	−0.12
Controls					
Meetings		Yes			
Horizons			Yes		
Individual				Yes (2.0%)	Yes (9.1%)
Individual ∗ slope					Yes (13.6%)
Wald statistics	79.22***	654.65***	303.04***	352.66***	2705.61***
Adjusted R^2	0.13	0.25	0.14	0.15	0.16
Observations	3084	3084	3084	3084	3084
			Panel B: Core PCE		
Constant	0.07***	−0.14	−0.04	0.11	−0.03
Slope	−0.24***	−0.26***	−0.23***	−0.23***	0.12
Controls					
Meetings		Yes			
Horizons			Yes		
Individual				Yes (2.0%)	Yes (3.0%)
Individual ∗ slope					Yes (68.2%)
Wald statistics	392.35***	936.18***	684.48***	1008.25***	3203.77***
Adjusted R^2	0.25	0.30	0.26	0.33	0.35
Observations	3084	3084	3084	3084	3084

[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.
[c.] The proportion of forecasters, whose fixed effects are significantly different from zero with the significance level of 5%, is listed in the parenthesis.

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

	(1)	(2)	(3)
Constant	1.30***	1.68***	1.17***
Slope	−0.63***	−0.66***	−0.65***
Fixed effects:			
Meetings		Yes	
Horizons			Yes
Wald statistics	706.39***	3630.69***	1319.39***
Adjusted R^2	0.87	0.87	0.88
Observations	202	202	202

[a.] This table shows the results of regressions testing Okun's law with different specifications, using the midpoints of the central tendency of the FOMC's aggregate projections.

[b.] Inference is based on heteroscedasticity and autocorrelation robust (HAC) standard errors. *** denotes the significance level at 1%.

Table 6: Estimates of Okun's Law (FOMC's Aggregate Projections)

	PCE			Core PCE		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	−0.04	−0.02	0.24	0.00	−0.12	0.12
Slope	−0.25***	−0.27***	−0.28***	−0.18***	−0.18***	−0.19***
Fixed effects						
Meetings		Yes			Yes	
Horizons			Yes			Yes
Wald statistics	14.03***	672.11***	37.62***	16.12***	1634.82***	39.58***
Adjusted R^2	0.10	−0.04	0.09	0.13	0.00	0.10
Observations	202	202	202	202	202	202

a. This table shows the results of regressions testing the Phillips curve with different specifications, using the midpoints of the central tendency of the FOMC's aggregate projections.

b. Inference is based on HAC standard errors. * and *** denote the significance level at 10% and 1%, respectively.

Table 7: Estimates of the Phillips Curve (FOMC's Aggregate Projections)

	PCE			Core PCE		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	1.81***	2.06***	3.05***	2.00***	2.15***	3.08***
Responses to						
Output Gap	−0.41***	−0.19**	−0.96***	−0.45***	−0.29***	−0.92***
Inflation Gap	1.53***	1.90***	0.32**	2.81***	3.31***	1.09***
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 8: Estimated Partial Effect of the Reaction Function Based on the Output Gap

Online Appendix for "The FOMC's New Individual Economic Projections and Macroeconomic Theories" by Natsuki Arai

Affiliations	GDP	Unemp.	PCE	Core PCE	FFR	Num. of Obs.
Atlanta	2.18	7.02	1.78	1.70	1.70	70
Philadelphia	2.50	6.47	2.04	1.92	1.97	70
Dallas	2.51	7.04	1.87	1.61	1.75	70
Cleveland	2.53	7.00	1.78	1.60	2.20	70
Minneapolis	2.54	6.99	1.82	1.75	1.48	70
Richmond	2.57	7.10	1.76	1.61	2.46	70
Governors	2.62	6.95	1.66	1.51	1.57	357
Kansas City	2.64	7.01	1.69	1.59	2.09	67
San Francisco	2.72	6.89	1.55	1.46	2.18	70
New York	2.80	6.87	1.80	1.64	1.52	70
Boston	2.80	6.92	1.44	1.29	2.06	70
St. Louis	2.80	6.82	1.95	1.80	1.06	70
Chicago	2.86	6.88	1.73	1.61	1.71	70
Standard Dev.	1.38	1.83	0.61	0.43	0.90	1194

[a.] This table shows the summary statistics of FOMC's individual projections between 2007 and 2011 and 2016, according to their affiliations. The table is sorted with the mean of GDP growth.

[b.] The mean is calculated as the average of projections across all forecast horizons except the long run.

Table A1: Summary Statistics of FOMC's Individual Projections with Identity

	(1)	(2)	(3)
Constant	0.77***	1.12***	0.78***
Slope	−0.45***	−0.43***	−0.53***
Fixed effects:			
Meetings		Yes	
Horizons			Yes
Wald statistics	1124.07***	4887.05***	3342.39***
Adjusted R^2	0.48	0.54	0.58
Observations	1854	1854	1854

[a.] This table shows the results of regressions testing Okun's law with different specifications, excluding the sample period of Great Recession from December 2007 to June 2009.
[b.] Inference is based on heteroscedasticity and autocorrelation robust (HAC) standard errors. *** denotes the significance level at 1%.

Table A2: Estimates of Okun's Law Excluding Great Recession (FOMC's Individual Projections)

	PCE			Core PCE		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	0.11*	−0.02	−0.02	0.04	−0.12**	−0.06
Slope	−0.03	−0.13***	0.00	−0.14***	−0.18***	−0.16***
Fixed effects						
Meetings		Yes			Yes	
Horizons			Yes			Yes
Wald statistics	9.56***	368.21***	160.34***	45.30***	1354.95***	104.50***
Adjusted R^2	0.00	0.13	0.03	0.06	0.22	0.11
Observations	1854	1854	1854	1854	1854	1854

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 A3: Estimates of the Phillips Curve Excluding Great Recession (FOMC's Individual Projections)

	PCE			Core PCE		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	2.18***	2.39***	1.55***	2.23***	2.32***	1.50***
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
Wald statistics	896.97***	1608.18***	2091.53***	961.94***	1806.72***	2459.05***
Adjusted R^2	0.60	0.64	0.70	0.61	0.64	0.70
Observations	1258	1258	1258	1258	1258	1258

[a.] This table shows the results of regressions testing the Taylor rule with two measures of inflation gap (PCE and Core PCE) and difference specifications.

[b.] Inference is based on heteroscedasticity and autocorrelation robust (HAC) standard errors. *** denotes the significance level at 1%.

Table A4: Estimates of the Response Function Based on the Linear Model (FOMC's Individual Projections)