Systematic Monetary Policy Approach to Taylor Rule

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First version: May, 2024

This version: May, 2024

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Abstract

This work estimates the time-(state-)varying Taylor rule by local projection model where states are indexed using FOMC members' preferences. I show that the dovish FOMC board delays policy rate hikes in response to increase in inflation projection. The FOMC hawkishness does not change the effect of effect shocks of output gap. Additionally, using the predictions generated by the estimated Taylor rule, I estimates historical values size and persistence.

Keywords: Systematic Monetary Policy, Taylor Rule, FOMC

JEL Codes: E52, E58, E43

1 Introduction

The conduct of monetary policy can be divided via two axis (see table 2 on the following page), whether the policy is systematic or unsystematic and whether the market expected the actions of monetary authority. The examples of monetary policy cells along the main diagonal of table 2 on the next page are the most frequently of systematic and unsystematic monetary policies – systematic policy is mostly anticipated and unsystematic is mostly not. But note that the off diagonal elements are not empty.

This work makes an attempt to estimate the time-varying monetary policy function assuming that the time dimension is guided by a FOMC preferences. That is, this works tries to estimate both the anticipated and unanticipated parts of the systematic monetary policy by using a FOMC preferences augmented Taylor Rule.

The conduct of monetary policy can be divided via two axis (see table 2 on the following page), the systematicality of a policy and the expectations of the market from the actions of monetary authority. The examples of monetary policy cells along the main diagonal of table 2 on the next page are the most frequent uses of systematic and unsystematic monetary policies, but note that the off diagonal elements are not empty. This work makes an attempt to estimate the time-varying monetary policy function assuming that the time dimension is guided by a FOMC preferences. That is, we try to estimate both the anticipated and unanticipated parts of the systematic monetary policy by using a FOMC preferences augmented Taylor Rule.

*Email: avlasov@nes.ru. For supplementary materials, code and datasets, see the repository on github.com. I thank Valery Charnavoki and Konstantin Styrin for helpful comments.

Table 1. Monetary Policy Taxonomy

	Systematic	Unsystematic
Anticipated	Known monetary policy function	Credible announcement of a transitory policy
Unanticipated	Changes to monetary policy function	Monetary shocks

Notes: The distinction and table is from Jorda and Hoover (2000), who use it with regards to central bank's money supply policy.

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	Systematic	Unsystematic
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Notes: The table is from Jorda and Hoover (2000), who use it with regards to central bank's policy of money supply.

1.1 Related literature

My work relates to several strands of literature. First, this work relates to the attempts of estimation of systematic monetary policy, and, the theme which is connected, Taylor rules estimation, which is a particular form of the anticipated systematic monetary policy.

1.1.1 Systematic Monetary Policy

The recent literature about systematic monetary policy identification focuses on measuring the distance between monetary policies (loss function), counterfactuals and optimal monetary policy functions. For example, a recent work by McKay and Wolf (2023) provides a methodology that uses many identified shocks and estimated responses to them, which, combined with structural assumptions and assumptions on stability of non-policy sector, allows them to estimate the monetary policy counterfactuals. Barnichon and Mesters (2023) using the similar methodology, are able to identify non-optimal policies without any structural assumptions.

Another approach to systematic monetary policy identification is Hack et al. (2023), who propose the usage of FOMC preferences to estimate the spectrum of estimates of propagation of government spending shock. This allow Hack et al. to estimate the government spending multiplier conditional on the monetary authority's preferences towards inflation. In my work I follow the similar approach, i.e. I use the FOMC preferences to estimate the Taylor rule-like policy with time-varying (state-varying, where state is indexed by FOMC preferences) effects of projected inflation/output gap.

1.1.2 Taylor Rules

Recent literature that specifies on Taylor rules is rather small. I would like to note Carvalho et al. (2021), who argue for estimation of Taylor rule using the OLS because the monetary policy shocks tend to explain only a small fraction of the overall variation of monetary instruments (i.e. Fed Funds rate, FFR). That is why the possible endogeneity bias caused by OLS estimate, they claim, will not be large. Aguiar-Conraria et al. (2018) use wavelet techniques (partial wavelet gain) to estimate the Taylor rule. They find a substantial changes in the Taylor Rule estimate throughout the time and frequencies.

The paper proceeds as follows. The next section thoroughly discloses the empirical strategy for estimating time-varying (or FOMC preference dependent) Taylor rule. Than I describe and the results and construct historical size and persistence estimates.

2 Empirical Strategy

2.1 Systematic Monetary Policy Identification

Further I follow Hack et al. (2023) approach to systematic monetary policy identification that is based on the use of Hawk-Dove balance as a measure of systematic monetary policy variation. Specifically, I assume that the monetary policy rule is

$$r_t - r_t^* = \tilde{\phi}_t^{\pi} \mathbb{E}_t \pi_{t+1} + \tilde{\phi}_t^{x} \mathbb{E}_t x_t + \varepsilon_t, \tag{1}$$

where r_t is the real rate of interest, r_t^* is the natural rate of interest π_{t+1}^e and x_{t+1}^2 are the monetary authority's expectations over the inflation and output gap. As one can see Then $\tilde{\phi}_t^j = \phi^j + \phi_t^j$ is the systematic monetary policy – that is, the time-dependent response of the monetary authority to the expected change in inflation/output.

The assumed monetary policy rule is essentially a Taylor rule, but also it can be viewed as a simplified time-varying version of Romer and Romer (2004) regression rule.

I estimate the following state-dependent local projection augmented with IV model[1]

$$\begin{aligned} r_{t+h} - r_{t+h}^* = \alpha^h + \delta^h \left(Hawk_t - \overline{Hawk} \right) & \\ + \beta_\pi^h \pi_t^e + \gamma_\pi^h \pi_t^e \left(Hawk_t - \overline{Hawk} \right) + \beta_x^h x_t^e + \gamma_x^h x_t^e \left(Hawk_t - \overline{Hawk} \right) & \\ + \zeta^h Z_t + e_{t+h}^h, & \end{aligned} \tag{2}$$

where $h = 0, \ldots, H$ are the forecast horizons. r_{t+h} is federal funds rate (bridged with Wu and Xia (2016) for the ZLB period) and r_{t+h}^* is the Laubach and Williams (2003) natural interest rate.[2] π_t^e is the measure of the FED expectation of future inflation. I use the average of T+1 and T+2 quarters tealbook forecasts following the approach by Coibion and Gorodnichenko (2011). $Hawk_t$ is the quarterly Hawk-Dove index of Hack et al. (2023), which is based on the Istrefi (2019) and Bordo and Istrefi (2023) estimation of individual policy preference of FOMC members expressed before each of the FOMC meeting in press; $\overline{Hawk}$ stand for the mean of this variable.

The vector of controls, Z_t, consists of the 4 lags of the dependent variable, $(r - r^*)_t$, 4 lags of the expected inflation, π_t^e, and 4 lags of expected gdp gap, x_t.

As Hack et al. (2023) suggest, the Hawk index, $Hawk_t$, can be potentially endogenous,[3] The

[1] See Jorda (2005); Plagborg-Møller and Wolf (2021); Òscar Jordà (2023) for theory on Local Projection, and specifically the latter on LP-IV.

[2] I use Holston et al. (2023) updated version of the Laubach and Williams (2003) natural rate.

[3] The FOMC member's preferences, although persistent, can reflect the changes in economic environment or preference of a president who appoints new members, which also may depend on the business cycle state.

proposed solution is to instrument $\left(Hawk_t - \overline{Hawk}\right)$ with the index of preferences of the rotating part of FOMC board[4] namely $\left(Hawk_t^{IV} - \overline{Hawk}^{IV}\right)$.

The instrument vector in this case is

$$\left[1 \quad \pi_t^e \quad x_t^e \quad \pi_t^e \times \left(Hawk_t^{IV} - \overline{Hawk}^{IV}\right) \quad x_t^e \times \left(Hawk_t^{IV} - \overline{Hawk}^{IV}\right)\right]$$

Note that the contemporaneous tealbook estimates of the GDP gap and CPI inflation are available only starting from 1987:Q3 and 1979:Q4, respectively. Also all Tealbook series are restricted 2018 Q4 due to 5 year publication lag, what leaves only 124 observations. In order to increase the time-span of the Taylor rule estimated in eq. (2) on the preceding page, I replace the projected CPI inflation with projected deflator inflation and projected GDP gap with projected unemployment gap.[5] Under the replaced measures of inflation and output gap (as unemployment gap) the sample size grows to 202 observations, starting from 1968:Q1.

So, I end up estimating 2 specifications: the specification with projected CPI inflation and projected GDP gap, which I name *short specification*, and the specification with projected GDP price inflation and unemployment gap, named *long specification*. Both specifications, assuming stable Okun's law (linear relation between GDP gap and unemployment gap), essentially measure the same Taylor rule, but using different measures for inflation and gap in economic activity.

Note that the IRFs LP estimator, unlike IRFs calculated from AR(-DL) models, do not exhibit the mean reversion property (which is a direct consequence of being robust AR model misspecification), which mean that for large horizons, H, estimates will be highly inaccurate due to elevated finite sample variance of the estimator (i.e. LP is less efficient than correctly specified AR-DL/VAR). Additionally, the fact that LP is instrumented additionally increases the variance of the estimator. For this reason I restrict the projection horizon to 20, $H = 20$ (5 years of quarterly observations), but note that the significance of the projections for the upper part of the horizon space should be viewed skeptically. For example, if the effects of a change in FOMC's projections become significant only after 10th quarter we should attribute this result to an estimator variation caused by a small sample (which in the case of short specification is only 122 observation). That is, for the robustness to model misspecification and semi-parametric nature of the LP model we pay with worse finite sample performance, so one need to be careful in interpretation of the effects that appear with significant lag.

2.2 Endogeneity Bias

Note that, ideally, in order to estimate eq. (2) on the previous page we want to instrument not only $Hawk_t$ but also the other main variables of interest, namely FOMC inflation and output gap projections. In order to find some orthogonal variation in projection of inflation/output gap one would need to identify the exogenous shocks to the information of the central bank. That is, we want to find the episodes of drastic change in economic projection of central bank, that were not caused by the underlying economic conditions. This remains the unsolved issue.

[4]Since 1940 each year 4/12 FOMC memberships rotate among 11 FRB presidents. Cleveland and Chicago get a seat every second year and Philadelphia, Richmond, Boston, Dallas, Atlanta, St. Louis, Minneapolis, San Francisco, Kansas City – every third year. By construction this rotation is independent of the business cycle.

[5]I define projected unemployment gap as the difference between tealbook projection of unemployment and projection of natural rate of unemployment (NAIRU). As previously, following Coibion and Gorodnichenko (2011), the projection is an average between T+1 and T+2 projections.

At the same time Carvalho et al. (2021) argues that because the monetary policy shocks tend to explain a small fraction[6] of the variance of regressors typically included in monetary policy rules, the endogeneity bias in Taylor Rule estimation with OLS is supposed be small.

3 Response of Monetary Policy to Projected Inflation and Output gap

Note that, ideally, in order to estimate eq. (2) on page 3 we want to instrument not only $Hawk_t$ but also the other main variables of interest, namely FOMC inflation and output gap projections. In order to find some orthogonal variation in projection of inflation/output gap one would need to identify the exogenous shocks to the information of the central bank. That is, we want to find the episodes of drastic change in economic projection of central bank, that were not caused by the underlying economic conditions. This remains the

3.1 Short Specification

The estimated coefficients of interest of the short regression can be found in fig. 1 and table 3 on the next page and on page 7. They are mean and differential response to a unit increase in tealbook projected CPI inflation and GDP gap. The differential responses is shown under the deviation of $Hawk_t$ from its mean equal to 2/12, which is slightly higher than one standard deviation of $Hawk_t$. This corresponds to a replacement of 2 of FOMC members with 2 consistent hawks.[7] The coefficients (without scaling) for for the main regressors of interest can be seen in table 3 on page 7.

The average response (i.e. the the response for average FOMC hawkishness) of the $(r - r^*)$ are larger than zero up on 95% confidence to 11th quarter. The point estimate of the immediate response (T) of $(r - r^*)$ to the increase of tealbook projected of CPI inflation is an increase by 0.175 percentage point. The response rises peak of 0.923 p.p. in the T+4 quarter, and then diminishes and becomes not significantly different from zero at T+11.

The impact of hawkishness of FOMC on the effect of a change in projected inflation becomes prominent after 3rd quarter and is negative. If the 2 FOMC members out of 12 were changed for hawkish FRB heads, it would reduce the response to inflation by 0.266 percentage in the T+3rd quarter, and the effect increases to 0.370 p.p in T+6th quarter. Note that the effect of hawks on response to inflation becomes not distinguishable from zero (at 10% significance level) starting from the T+7th quarter.

The average response of $(r - r^*)$ to the increase in tealbook projected gdp gap of 1 p.p. is 0.177 on impact (at T) and it increases a peak of 0.815 in T+6. The influence of FOMC preferences appears only on impact (T) – additional 2/12 hawks in FOMC increase the response by 0.015 p.p., and since T+17, and I treat the latter as a result attributed to the variance of estimator.

So, the FOMC hawkishness does decrease the response to projected CPI inflation (by doing so it shrinks the period of response of monetary authority to a shock of an increase of expected inflation),

[6] Also note that due to the increasing use of policies that rely on expectations management (i.e. forward guidance), central banks have become more opened, what leads to decrease in share of movement in rates due to monetary policy shocks.

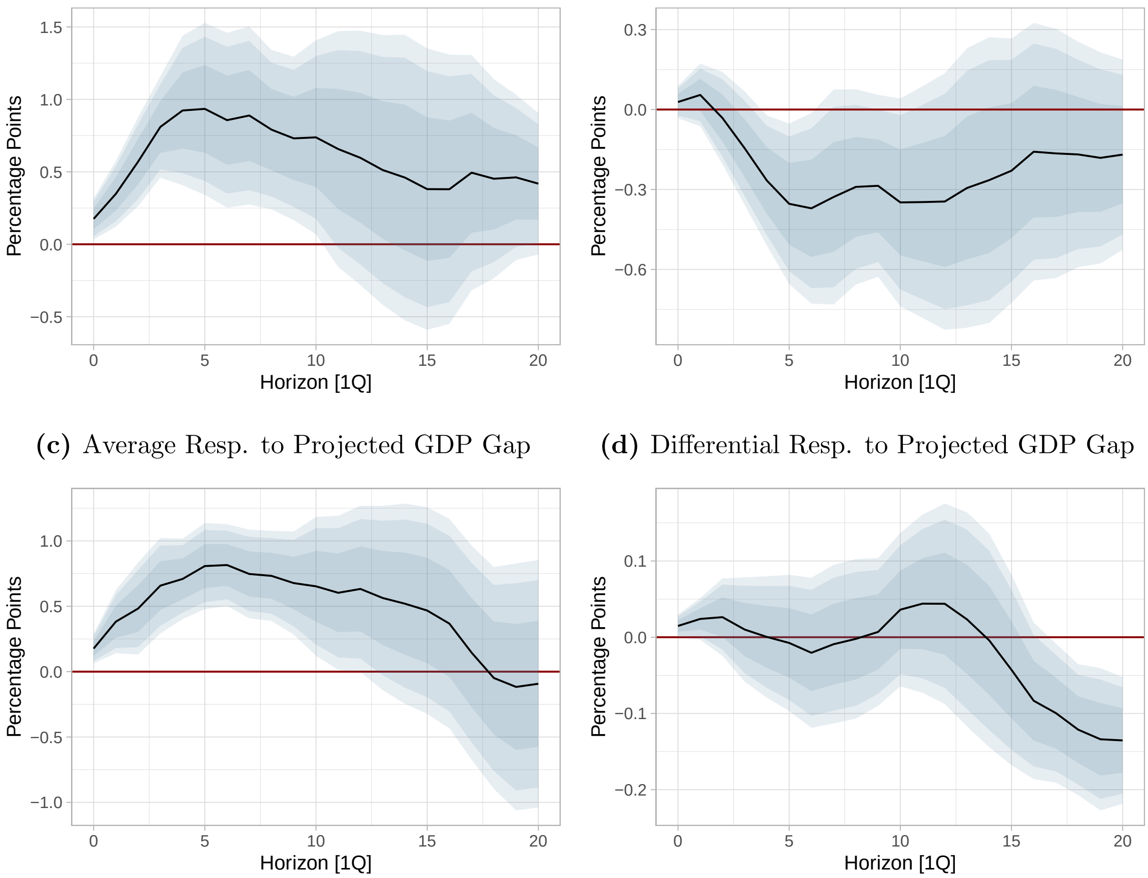
[7] Consistent hawk is a FRB governor that was not classified as dove priorly, additional consistent hawk increases *Hawk* index by 1/12. For detailed discussion of *Hawk* index construction see appendix A on page 15.

but has little to no effect on the response to an increase in projected GDP gap.

Figure 1. Policy Response to Inflation and FOMC Hawkishness. Short Specification

(a) Average Resp. to Projected CPI Inflation **(b)** Differential Resp. to Projected CPI Inflation

(c) Average Resp. to Projected GDP Gap **(d)** Differential Resp. to Projected GDP Gap



Notes: This figure reports the responses of the $(r - r^*)_t$ to an increase in the Tealbook CPI inflation forecast and GDP gap forecast of 1 p.p. The subfigure 1a reports the response of $(r - r^*)_t$ to projected CPI inflation for the *HAWK* index equal to the sample average; 1b is the addition to the response in case there are 2 (out of 12 in total) additional consistent hawks in the FOMC. Subfigures 1c and 1d report the same for the increase in projected GDP gap for 1p.p. The shaded areas correspond to 68%, 90% and 95% confidence bands calculated with Andrews (1991) HAC estimator.

3.2 Long Specification

The coefficients of interest of long specification of Taylor Rule can be found in table 4 on page 9 and impulse responses can be found in fig. 2 on page 8. Note that, in order to look similar to the short specification, the IRFs of deviation of rate from its natural level are calculated with for a shock of decrease (signified by down pointing arrow, $\downarrow$) in unemployment gap.

The point estimate of response of the $r - r^*$ to a 1 p.p. increase in projected deflator inflation under $Hawk_t = \overline{Hawk}$ in period T is not significantly different from 0, and it rises to 0.518 in period T+2 and quickly becomes insignificant at T+4.

The estimate of impact of hawkishness of FOMC on the response of $r - r^*$ is significant in period T and equal to additional 0.12 p.p. for a change in Hawk index by 2/12. The impact steadily increases and reaches addition of 0.58 in period T+6 for 2/12 FOMC hawks to a response to projected deflator inflation. The effect declines and becomes not significantly different from zero at T+7 quarter.

The point estimate of immediate (T) response of $r - r^*$ to decrease in unemployment gap,assuming the average hawkishness of FOMC, is equal to 1.19 p.p. The estimate of IRF increases to the maximum

Table 3. Estimates of LP Taylor Rule. Short Specification

	Dependent variable: $(r - r^*)_{t+h}$						
	$h = 0$	$h = 2$	$h = 4$	$h = 6$	$h = 8$	$h = 10$	$h = 12$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Projected CPI Inflation, ΔCPI_t^e	0.175^{**}	0.570^{***}	0.923^{***}	0.856^{***}	0.791^{***}	0.738^{**}	0.596
	(0.073)	(0.157)	(0.263)	(0.308)	(0.281)	(0.342)	(0.448)
$\times \left(Hawk_t - \overline{Hawk}\right)$	0.170	−0.191	-1.600^{**}	-2.224^{**}	−1.741	-2.091^{*}	-2.070^{*}
	(0.186)	(0.530)	(0.749)	(1.094)	(1.122)	(1.193)	(1.193)
Projected GDP Gap, x_t^e	0.177^{***}	0.483^{***}	0.709^{***}	0.815^{***}	0.733^{***}	0.653^{**}	0.633^{*}
	(0.058)	(0.180)	(0.157)	(0.160)	(0.176)	(0.271)	(0.325)
$\times \left(Hawk_t - \overline{Hawk}\right)$	0.089^{*}	0.158	0.002	−0.122	−0.013	0.217	0.263
	(0.046)	(0.156)	(0.244)	(0.302)	(0.320)	(0.308)	(0.308)
Observations	122	122	122	122	122	120	118
R^2	0.983	0.912	0.784	0.647	0.528	0.416	0.373
Adjusted R^2	0.981	0.898	0.749	0.590	0.451	0.318	0.266
Residual Std. Error	0.322	0.716	1.063	1.295	1.457	1.582	1.622
Wu-Hausman F	0.395	0.352	0.718	1.891	6.496^{***}	15.97^{***}	15.05^{***}
	[0.757]	[0.788]	[0.543]	[0.136]	[0.001]	[0.000]	[0.000]

Notes: This table reports the estimates of the coefficients of interest in model in eq. (2) on page 3 with projected inflation measured as a projected change in CPI and projected output gap is measured by projected GDP gap. The Andrews (1991) HAC standard errors are in parenthesis. All of the coefficients can be seen in table B.1 on page 17. Weak Instrument F-statistics (for $h = 0$) are HAWK: 53.5***; interaction with CPI inflation: 42.2***, interaction with GDP gap: 51.4***. Wu-Hausman stands for a test statistic that corresponds to 2SLS test for endogeneity, p-value is in brackets below. The period of estimation is from 1987 Q3 to 2018 Q4. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

of 1.99 p.p. in period T+6, and looses the significance at T+10.

The estimate of differential impact is significant at 10% only on impact (at T), the point estimate is equal to 0.015 percentage point, and not significant for other horizons.

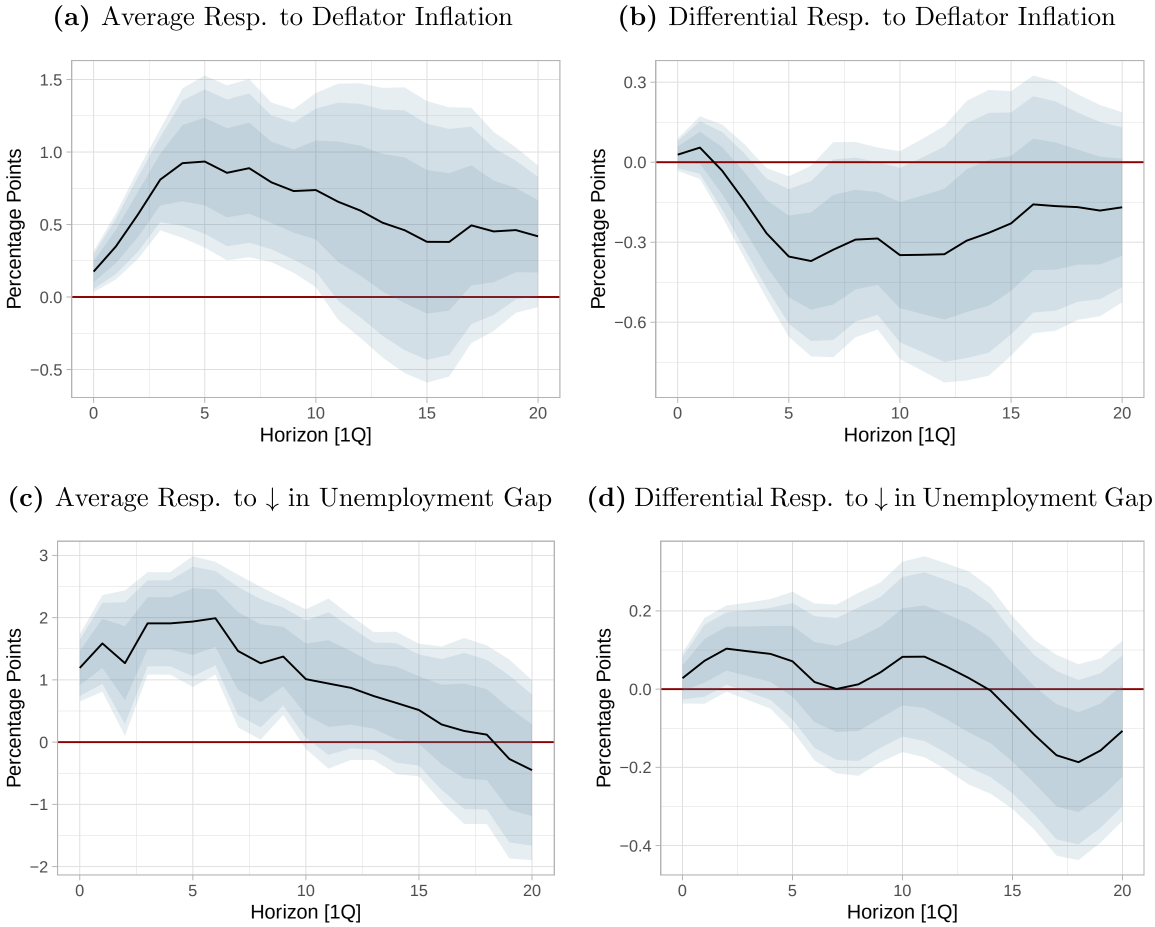
Hack et al. (2023) (in appendix named "Validation Exercise") estimates the model similar to eq. (2) on page 3 under long specification, but under assumption that the systematic monetary policy responds only to inflation. My estimates in fig. 2 on the next page and table 4 on page 9 average and differential responses of $r_t - r_t^*$ to CPI inflation tend to be smaller compared to the estimations of Hack et al. (2023). The difference is due to the fact that Hack et al. (2023) 1) do not correct the fed funds rate for the natural rate of interest, i.e. estimate the response of r_t, and 2) assume that the monetary authority systematic policy respond only to inflation.

The essential difference in dynamics between short and long specification is in the responses to inflation, specifically in the balance between average and differential responses. In short specification the FOMC hawkishness plays less important role, it quickly looses the significance compared to the long specification. Additionally, the fact that hawkishness of FOMC does not increase the response to the CPI inflation, but does increase the response to deflator inflation is disturbing.

3.3 Endogeneity Test

To test the endogeneity (i.e. the fact that 3 instruments change the coefficients on instrumented variables) I calculate Wu-Hausman F statistic (see fig. 3b on page 9 for the statistic for each horizon). We can reject the null of equivalence of LP and LP-IV for short specification starting from $h = 8$ and for long specification from the contemporaneous prediction up to $h = 11$ at 5% significance level.

Figure 2. Policy Response to Projected Deflator Inflation and Unemployment Gap and FOMC Hawkishness. Long Specification



Notes: This figure reports the responses of the $(r - r^*)_t$ to an increase in the Tealbook deflator inflation forecast and *decrease* unemployment gap forecast of 1 p.p. The subfigure 2a reports the response of $(r - r^*)_t$ to projected deflator inflation for the *HAWK* index equal to the sample average; 2b is the addition to the response in case there are 2 (out of 12 in total) additional consistent hawks in the FOMC. Subfigures 2c and 2d report the same for the decrease in projected unemployment gap for 1p.p. The shaded areas correspond to 68%, 90% and 95% confidence bands calculated with Andrews (1991) HAC estimator.

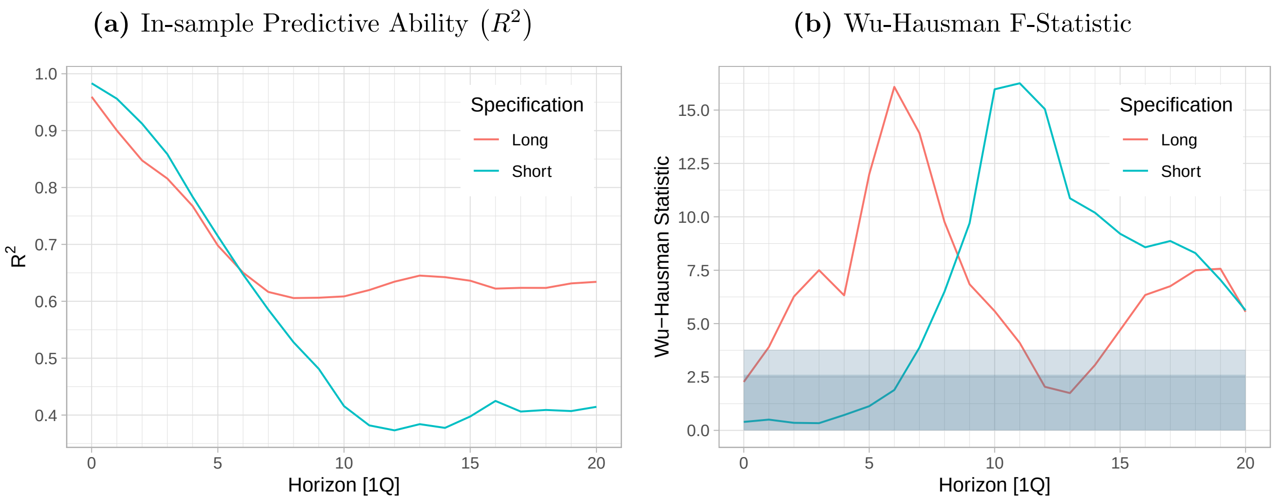
Table 4. Estimates of LP Taylor Rule. Long Specification

	Dependent variable: $(r - r^*)_{t+h}$						
	$h = 0$	$h = 2$	$h = 4$	$h = 6$	$h = 8$	$h = 10$	$h = 12$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Projected Deflator Inflation, $\Delta Deflator_t^e$	0.235	0.518^{**}	0.691^{*}	0.718	0.681	0.331	0.178
	(0.146)	(0.235)	(0.354)	(0.587)	(0.613)	(0.455)	(0.353)
$\times \left(Hawk_t - \overline{Hawk}\right)$	0.716^{**}	1.554^{**}	2.216^{***}	3.466^{***}	2.588^{**}	1.612	0.507
	(0.292)	(0.654)	(0.510)	(1.105)	(1.306)	(1.347)	(1.320)
Projected Unemployment Gap, $(u - u^*)_t^e$	-1.192^{***}	-1.268^{**}	-1.908^{***}	-1.991^{***}	-1.267^{**}	-1.012^{*}	-0.871
	(0.275)	(0.597)	(0.420)	(0.462)	(0.627)	(0.573)	(0.591)
$\times \left(Hawk_t - \overline{Hawk}\right)$	-0.168	-0.621^{*}	-0.541	-0.109	-0.074	-0.495	-0.345
	(0.198)	(0.338)	(0.430)	(0.615)	(0.716)	(0.746)	(0.808)
Observations	200	200	200	200	200	198	196
R^2	0.960	0.848	0.768	0.650	0.606	0.609	0.634
Adjusted R^2	0.956	0.833	0.746	0.618	0.569	0.572	0.600
Residual Std. Error	0.741	1.438	1.775	2.183	2.332	2.331	2.265
Wu-Hausman F	2.268^{*}	6.267^{***}	6.322^{***}	16.09^{***}	9.765^{***}	5.584^{***}	2.04
	[0.082]	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]	[0.11]

Notes: This table reports the estimates of the coefficients of interest in model in eq. (2) on page 3 with projected inflation measured as a projected change in GDP deflator and projected gap is the gap in unemployment. The Andrews (1991) HAC standard errors are in parenthesis. Weak Instrument statistics (for $h = 0$) are the following, hawk: 64.8; interaction with deflator inflation: 64.2, interaction with unemployment gap: 79.5. Wu-Hausman F is a F-form statistic for 2SLS test for endogeneity, p-value is in brackets below. The period of estimation is from 1968 Q1 to 2018 Q4. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Note that this is a sequential test, so one need to be careful in result interpretation.

Figure 3. Additional Statistics for LP Models



Notes: This figure reports the R^2 and Wu-Hausman F statistic (for 2SLS test for endogeneity) of the short and long specifications of eq. (2) on page 3 model. The shaded area correspond to the 5% and 1% not-rejection regions for the Wu-Hausman endogeneity F statistic.

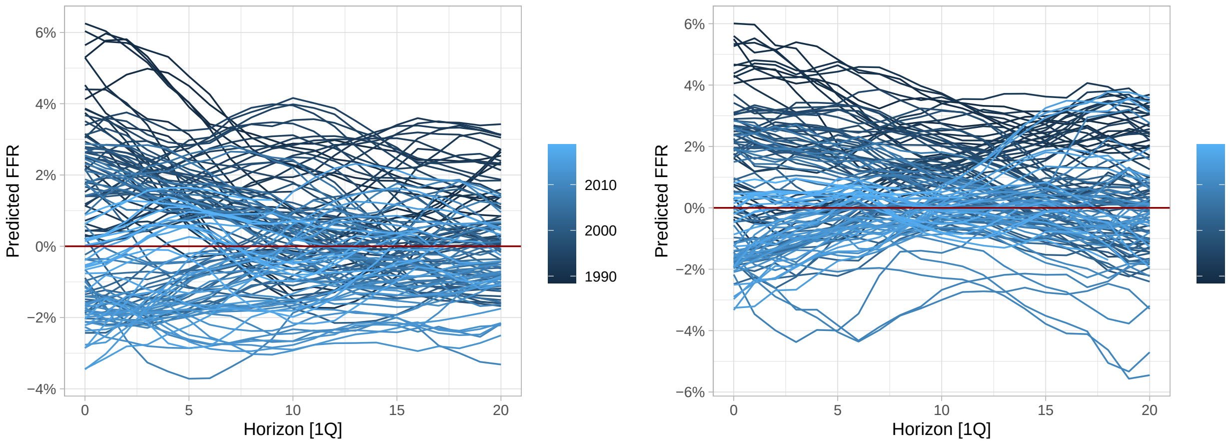
3.4 Predictions

One of the advantages of using state-dependent local projection framework is that we can look at the fitted values as a predictions of FFR paths made in each period of time. LP model is the best linear predictor of the $(r - r^*)_{t+h}$ made from information known at t, namely the expectations of FOMC and the FOMC preferences with respect to the speed of rate adjustment. The fig. 4 on the next page shows the point-predictions made using the model eq. (2) on page 3 based on the FOMC composition and tealbook projections of inflation and output gap (for different specifications).

The fig. 3a on the previous page show R^2 for different prediction horizons. One can note that the LP-IV model has good predictive abilities in short horizons.[8] The R^2 for $h = 0$ is 0.98 and 0.96 for short and long specifications respectively. It remains larger than 0.8 for the 3 quarters after the monetary policy decision. In-sample predictive ability deteriorates quickly after the 3rd quarter after the quarter of decision and stabilizes on the levels around 0.4 for short specification, and around 0.625 for long specification. The difference in R^2 between two specification is probably due to the stability of predictions in the period before 1988 Q3.

Figure 4. Predictions of FFR Paths Made in Each of the Period

(a) Short Specification **(b)** Long Specification



Notes: This figure shows the eq. (2) on page 3 model predictions of FFR rate paths made in each period of time for 2 specifications. The prediction period is 1988 Q3 to 2018 Q4 for both specifications.

3.5 Historical Estimates of Size and Persistence

The predicted interest rate paths are naturally hard to analyze, so one of the ways to look at them, which is inspired by the size-persistence tradeoff in heterogeneous agent new keynesian model (HANK) by Kaplan et al. (2018), is to estimate the size and persistence of monetary policy.

First, I restrict the prediction horizon to $H = 12$ quarters ahead, because after T+12 there is no significant coefficients of interest, and predictive abilities plateaued. Essentially, $H = 12$ is equivalent to assumption that in 3 years after the shock of projected inflation/output gap happened the monetary policy has fully reacted and the cycle of contractionary/expansionary of policy has finished.

Deviating from Kaplan et al. (2018), I define the size as a mean of predicted rate path.[9]

The persistence can be calculated by fitting the model

$$(r - r^*)_h = \exp(\mu h)\,(r - r^*)_0 \exp(\varepsilon_h),$$

where h is the projection horizon $h = 0, \ldots, 12$. The persistence is then equal to $\exp(\mu)$.[10] Note that

[8] This result is similar to the result of Carvalho et al. (2021) for specification with projection of CPI inflation and projection GDP gap.

[9] Kaplan et al. (2018) define size as a integral of deviation of rate of interest from natural rate for the whole duration of the policy, i.e. $\int_0^T (r_t - r^*)\, dt$. If we discretize it, it can be written as a sum, the size in my definition is a sum scaled by $1/(T+1)$.

[10] Note that in HANK model by Kaplan et al. (2018) the μ was assumed to be negative and $r_0 - r_0^*$ was assumed

it can be rewritten as

$$\log\left(\frac{(r-r^*)_h}{(r-r^*)_0}\right) = \mu h + \varepsilon_h,$$

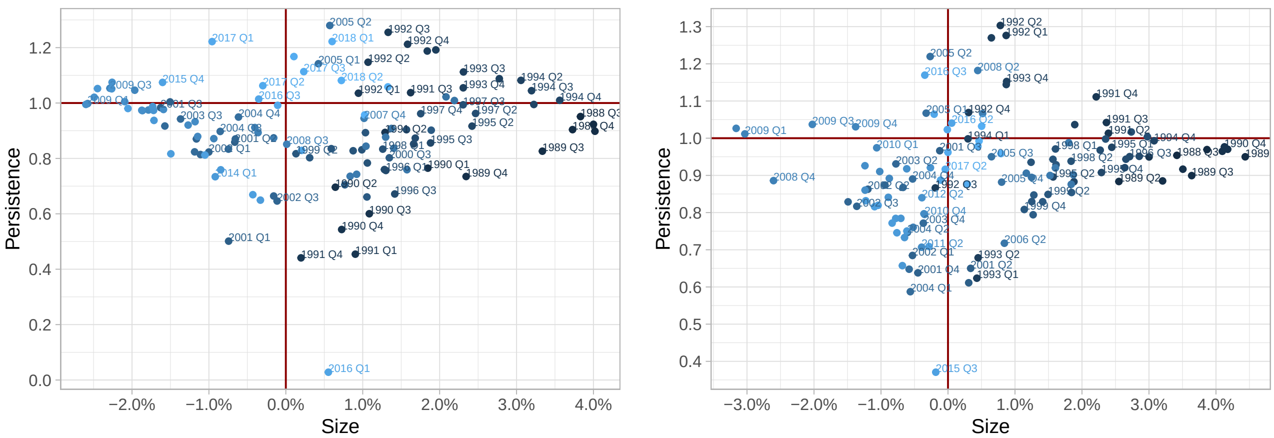
which can be estimated with OLS for each projection, and then the desired estimator of $\exp(\mu)$ is $\exp(\hat{\mu})$.

You can find the estimates of size and persistence in fig. 5 (on size-persistence as x-y axis) and in fig. 6 on the following page (on size-quarter, persistence-quarter axes). If size is greater than 0 then the model in eq. (2) on page 3 predicts the contractionary monetary policy in the future, and if size is less than 0 then the predicted policy is expansionary. If persistence is smaller than 1 then the model predicts normalization of monetary policy for future horizons. The periods when persistence is larger than 1 are the periods for which the expectation is the future increase of $r_t - r_t^*$ if policy is contractionary or future decrease of $r_t - r_t^*$ if the policy is expansionary.

Most of the points-quarters (about 42% for short and 41% for long specifications in period between 1988 Q3 and 2018 Q4, see table 5) are observe persistence below 1 and size above zero, that is in most periods in 1988 Q3 – 2018 Q4 the estimated model predicted a contractionary monetary policy that normalizes further.

Figure 5. Historical Estimates of Size and Persistence

(a) Short Specification **(b)** Long Specification



Notes: This figure shows the size and persistence calculated as described in section 3.5 on the previous page for 2 specifications for period from 1988 Q3 to 2018 Q4 (the period of estimation of short specification).

Table 5. Shares of Quarters in Size-Persistence Quadrants

	Short Specification		Long Specification	
	$\text{Size}_t < 0$	$\text{Size}_t > 0$	$\text{Size}_t < 0$	$\text{Size}_t > 0$
$\text{Persistence}_t > 1$	9.84%	18.03%	7.38%	13.11%
$\text{Persistence}_t < 1$	31.96%	40.16%	36.07%	43.44%

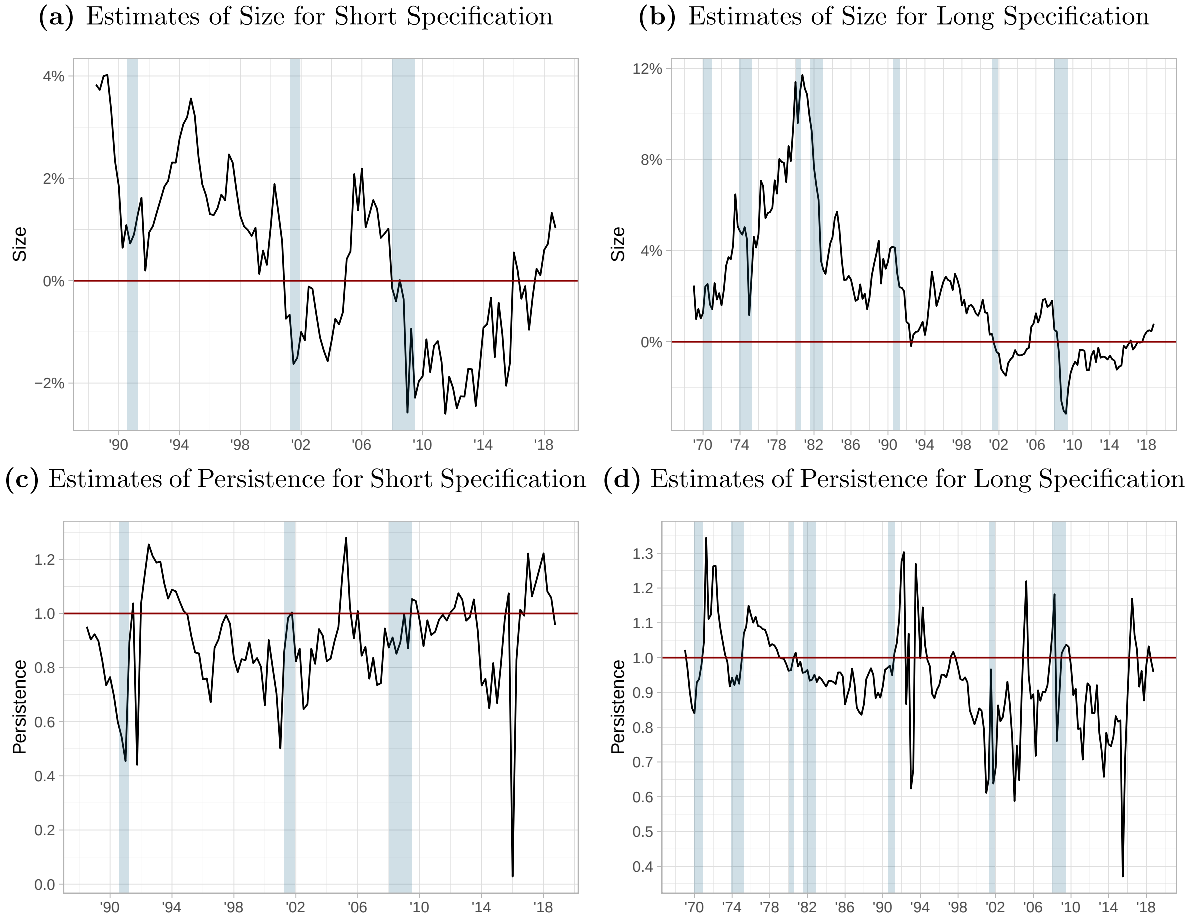
Notes: This table presents shares of size and persistence estimates for short and long specifications for period from 1988 Q3 to 2018 Q4 in different quadrants of size-persistence plane in fig. 5. If in t $\text{Size}_t > 0$ then the prediction of monetary policy path is contractionary (and vice versa), if $\text{Persistence}_t < 1$ then the predicted monetary policy path is a normalization of policy.

Note that for both specifications the size plots and persistence plots (fig. 6 on the next page)

to be positive, that is Kaplan et al. (2018) was focused on contractionary shock of r_0 which follow the $(r-r^*)_t = \exp(\mu t)\,(r-r^*)_0$ process.

the dynamics generally look quite similar in the region of intersection (starting from 1988), but the peak points of estimates of persistence do seem to be quite different, even if peaks timing is similar. Additionally, we see that the size decreases in time of recessions, the persistence estimate is are less than 1 at the start of the crisis and it sometimes grow to the end of the recession. This statement about persistence applies to GFC (2008 Q1 – 2009 Q3), 1990 Q3 – 1991 Q2 recession and 1973-1975 recession, but not to 2001 recession, 1981 Q3 – 1982 Q4 recession.

Figure 6. Size and Persistence Dynamics



(a) Estimates of Size for Short Specification

(b) Estimates of Size for Long Specification

(c) Estimates of Persistence for Short Specification

(d) Estimates of Persistence for Long Specification

Notes: This figure shows the size and persistence for long and short specifications plotted against quarter they formed in. The size and persistence calculation is described in section 3.5 on page 10. NBER recessions are shaded.

4 Conclusion

This work estimates the state-dependent local projection model augmented with instrument, where state is indexed by preferences of FOMC board. I find that the more the dovish FOMC board postpones policy rate hikes in response to increase in inflation projection, but the effect is on the verge of significance for some specifications (namely if inflation is measured as CPI inflation). The FOMC preferences with regards to inflation have small effect on the monetary response to change in output gap. Additionally, based on the in-sample predictions of the monetary policy paths, I construct size and persistence estimates. I find that for most of the periods ($\approx 70\%$) in 1988 Q3 to 2018 Q4 the persistence is smaller than 1, which mean that in about 70% of quarters the model predicts the normalization of the monetary policy.

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A Appendix. Data and Data Sources

HAWK and HAWK IV Indexes. Istrefi (2019) classifies each FOMC member as hawk or dove based on more than 20,000 historical media articles. Istrefi (2019) categorizes FOMC member for each FOMC meeting based on the news information available up to the meeting. Hawks are perceived to be more concerned about inflation, while doves are more concerned with employment and growth. Bordo and Istrefi (2023) show that educational background (Freshwater vs. Saltwater) and crises experience of FOMC member predict their policy preferences.

Hack et al. (2023) aggregate this classification as follows. First, they define the policy preferences of each FOMC member i at meeting τ, $Hawk_{i\tau}$, as

$$Hawk_{i\tau} = \begin{cases} +1 & \text{Consistent hawk} \\ +\frac{1}{2} & \text{Swinging hawk} \\ 0 & \text{Preference unknown} \\ -\frac{1}{2} & \text{Swinging dove} \\ -1 & \text{Consistent dove} \end{cases}.$$

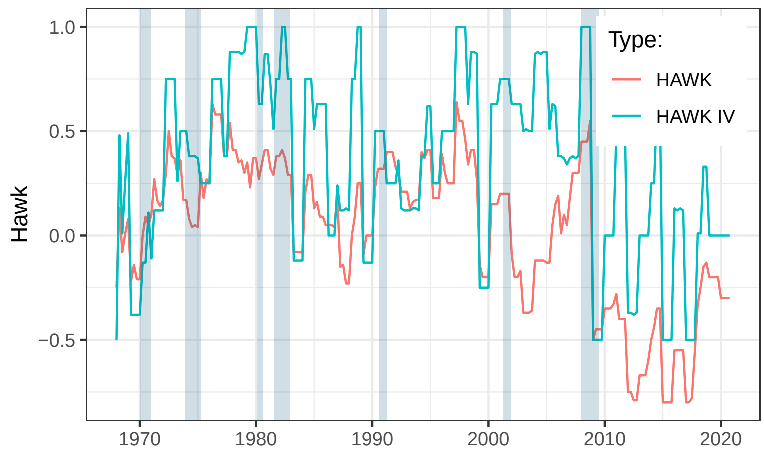
A consistent hawk is a member that has not been categorized as a dove previously, in contrast a swinging hawk is a member that was a dove before. Then the hawkishness of the bord at meeting τ is the average of the members present, that is

$$Hawk_\tau = \frac{1}{|\mathcal{M}_\tau|} \sum_{i \in \mathcal{M}_\tau} Hawk_{i\tau}.$$

Then $Hawk_\tau$ is aggregated to the quarterly level into $Hawk_t$, which is used in this work.

$Hawk_t^{IV}$ is constructed the similar way but on the portion of the FOMC memberships that is rotated each year. Each year 4/12 FOMC memberships rotate among 11 FRB presidents (Cleveland and Chicago get a seat every second year and Philadelphia, Richmond, Boston, Dallas, Atlanta, St. Louis, Minneapolis, San Francisco, Kansas City – every third year) and this rotation is independent of cycle.

Figure A.1. Hawk Index



Notes: Hawk and Hawk IV indices from Hack et al. (2023). NBER recessions are shaded.

Federal Funds Rate. To measure r_t I take the minimum of the effective federal funds rate (DFF) and shadow federal funds rate by Wu and Xia (2016). This approach allows me to deal the zero lower bound episode and have a measure of the the estimate by Wu and Xia (2016) to periods earlier than (1990 Q1) zero lower bound episodes.

Natural Rate Estimates. Natural rate of interest used is estimated by Laubach and Williams (2003) and re-estimated by Holston et al. (2023) to bridge the Covid period.

Tealbook Projections. Tealbook Projections are from Federal Reserve Bank of Philadelphia, the projection of CPI inflation is named *gPCPI* (Greenbook projections for Q/Q headline CPI inflation); the projection of GDP deflator inflation is named *gPGDP* (Greenbook projections for Q/Q growth in price index for GDP, chain weight); unemployment projection series is named *UNEMP* (Greenbook projections for the unemployment rate); natural unemployment projection is named "NAIRU Estimates from the Board of Governors" and GDP gap projection is named "real-time estimates and projections of the output gap used by the staff of the Board of Governors of the Federal Reserve System."

B Appendix. Full Regression Tables

Table B.1. Estimates of LP Taylor Rule. Short Specification

	Dependent variable: $(r - r^*)_{t+h}$						
	$h = 0$	$h = 2$	$h = 4$	$h = 6$	$h = 8$	$h = 10$	$h = 12$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Projected CPI Inflation, ΔCPI^e_t	0.175**	0.570***	0.923***	0.856***	0.791***	0.738**	0.596
	(0.073)	(0.157)	(0.263)	(0.308)	(0.281)	(0.342)	(0.448)
$\times \left(Hawk_t - \overline{Hawk}\right)$	0.170	−0.191	−1.600**	−2.224**	−1.741	−2.091*	−2.070
	(0.186)	(0.530)	(0.749)	(1.094)	(1.122)	(1.193)	(1.473)
Projected GDP Gap, x^e_t	0.177***	0.483***	0.709***	0.815***	0.733***	0.653**	0.633*
	(0.058)	(0.180)	(0.157)	(0.160)	(0.176)	(0.271)	(0.325)
$\times \left(HAWK - \overline{HAWK}\right)_t$	0.089*	0.158	0.002	−0.122	−0.013	0.217	0.263
	(0.046)	(0.156)	(0.244)	(0.302)	(0.320)	(0.308)	(0.403)
$\left(HAWK - \overline{HAWK}\right)_t$	−0.146	0.875	3.991*	6.539**	7.241**	8.725**	7.998**
	(0.446)	(1.321)	(2.151)	(3.167)	(3.432)	(3.640)	(3.928)
$(r - r^*)_{t-1}$	1.308***	1.454***	0.962***	0.423	−0.050	−0.464	−0.938
	(0.143)	(0.302)	(0.351)	(0.415)	(0.443)	(0.551)	(0.685)
$(r - r^*)_{t-2}$	−0.274	−0.666***	−0.548	−0.050	0.336	0.220	0.263
	(0.207)	(0.231)	(0.342)	(0.391)	(0.394)	(0.520)	(0.580)
$(r - r^*)_{t-3}$	−0.244	−0.458***	−0.059	0.030	−0.036	0.148	0.328
	(0.156)	(0.177)	(0.306)	(0.365)	(0.377)	(0.376)	(0.385)
$(r - r^*)_{t-4}$	0.031	0.145	−0.172	−0.612	−0.990***	−1.140***	−1.076**
	(0.098)	(0.236)	(0.346)	(0.376)	(0.358)	(0.441)	(0.503)
ΔCPI^e_{t-1}	0.005	0.093	−0.005	0.076	0.089	0.170	0.290
	(0.071)	(0.101)	(0.137)	(0.172)	(0.163)	(0.228)	(0.241)
ΔCPI^e_{t-2}	0.057	0.184	0.030	−0.062	0.005	0.177	0.340
	(0.084)	(0.188)	(0.287)	(0.320)	(0.351)	(0.357)	(0.355)
ΔCPI^e_{t-3}	0.134*	0.084	0.181	0.249	0.270	0.433	0.459*
	(0.069)	(0.128)	(0.187)	(0.255)	(0.274)	(0.277)	(0.236)
ΔCPI^e_{t-4}	−0.077	−0.127	−0.007	0.200	0.575***	0.901***	1.183***
	(0.056)	(0.121)	(0.184)	(0.168)	(0.173)	(0.248)	(0.273)
x^e_{t-1}	−0.057	−0.208	−0.340*	−0.567***	−0.529**	−0.494**	−0.412*
	(0.089)	(0.166)	(0.183)	(0.181)	(0.231)	(0.238)	(0.243)
x^e_{t-2}	−0.102	−0.064	0.107	0.268	0.251	0.417**	0.371*
	(0.074)	(0.127)	(0.194)	(0.229)	(0.212)	(0.202)	(0.224)
x^e_{t-3}	0.044	−0.023	−0.427**	−0.644**	−0.669*	−0.715	−0.704
	(0.099)	(0.118)	(0.191)	(0.286)	(0.354)	(0.449)	(0.488)
x^e_{t-4}	0.022	−0.010	0.072	0.182	0.326	0.378	0.427
	(0.062)	(0.112)	(0.202)	(0.240)	(0.240)	(0.275)	(0.311)
Constant	−0.546**	−1.428**	−1.829	−1.944	−2.587	−3.800**	−4.825**
	(0.219)	(0.666)	(1.174)	(1.614)	(1.801)	(1.907)	(2.002)
Observations	122	122	122	122	122	120	118
R^2	0.983	0.912	0.784	0.647	0.528	0.416	0.373
Adjusted R^2	0.981	0.898	0.749	0.590	0.451	0.318	0.266
Residual Std. Error	0.322	0.716	1.063	1.295	1.457	1.582	1.622
Wu-Hausman F	0.395	0.352	0.718	1.891	6.496***	15.97***	15.05***

Notes: This table reports the estimates of all of the coefficient in model in eq. (2) on page 3 with projected inflation measured as a projected change in CPI and projected output gap is measured by projected GDP gap. The Andrews (1991) HAC standard errors are in parenthesis. Weak Instrument statistics (for $h = 0$) are HAWK: 53.5; interaction with CPI inflation: 42.2, interaction with GDP gap: 51.4. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table B.2. First Stage of the Short Specification of LP Model (2)

	Dependent variable:		
	$\left(Hawk_t - \overline{Hawk}\right)$	$\times CPI_t^e$	$\times x_t$
	(1)	(2)	(3)
Expected CPI Inflation, ΔCPI_t^e	0.017	0.057	0.127**
	(0.034)	(0.084)	(0.055)
$\times \left(HAWK^{IV} - \overline{HAWK}^{IV}\right)_t$	−0.124***	0.144	−0.168**
	(0.044)	(0.109)	(0.071)
Expected GDP Gap, x_t^e	0.022	0.039	0.032
	(0.028)	(0.070)	(0.046)
$\times \left(HAWK^{IV} - \overline{HAWK}^{IV}\right)_t$	0.031**	0.030	−0.258***
	(0.016)	(0.038)	(0.025)
$\left(HAWK^{IV} - \overline{HAWK}^{IV}\right)_t$	0.776***	0.779***	0.408**
	(0.108)	(0.267)	(0.175)
$(r - r^*)_{t-1}$	0.041	−0.018	−0.125
	(0.052)	(0.128)	(0.084)
$(r - r^*)_{t-1}$	−0.013	0.003	0.030
	(0.082)	(0.203)	(0.133)
$(r - r^*)_{t-1}$	−0.041	0.081	−0.062
	(0.082)	(0.203)	(0.133)
$(r - r^*)_{t-1}$	0.090*	0.061	−0.021
	(0.048)	(0.118)	(0.077)
ΔCPI_{t-1}^e	−0.002	0.037	0.110*
	(0.038)	(0.093)	(0.061)
ΔCPI_{t-2}^e	0.047	0.052	0.140**
	(0.039)	(0.095)	(0.062)
ΔCPI_{t-3}^e	0.011	0.066	0.070
	(0.037)	(0.091)	(0.059)
ΔCPI_{t-4}^e	0.014	0.092	0.056
	(0.033)	(0.081)	(0.053)
x_{t-1}^e	−0.016	−0.051	−0.016
	(0.047)	(0.116)	(0.076)
x_{t-2}^e	−0.007	0.053	0.044
	(0.045)	(0.112)	(0.073)
x_{t-3}^e	0.002	−0.087	−0.042
	(0.043)	(0.107)	(0.070)
x_{t-4}^e	0.004	0.015	0.126***
	(0.030)	(0.073)	(0.048)
Constant	−0.340***	−0.843***	−1.058***
	(0.076)	(0.188)	(0.123)
Observations	122	122	122
R^2	0.857	0.814	0.866
Adjusted R^2	0.833	0.783	0.844
Residual Std. Error	0.162	0.399	0.261
F Statistic	36.591***	26.699***	39.550***
Weak instrument F	53.576	42.241	51.408

Notes: This table presents the first stage of LP-IV model estimation in eq. (2) on page 3 with projected inflation measured as a projected change in CPI and projected output gap is measured by projected GDP gap. The Andrews (1991) HAC standard errors are in parenthesis. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table B.3. Estimates of Long LP Taylor Rule

	Dependent variable: $(r - r^*)_{t+h}$						
	$h = 0$	$h = 2$	$h = 4$	$h = 6$	$h = 8$	$h = 10$	$h = 12$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Projected Deflator Inflation, $\Delta Deflator^e_t$	0.235 (0.235)	0.518** (0.235)	0.691* (0.354)	0.718 (0.587)	0.681 (0.613)	0.331 (0.455)	0.178 (0.353)
$\times \left(Hawk_t - \overline{Hawk}\right)$	0.716** (0.292)	1.554** (0.654)	2.216*** (0.510)	3.466*** (1.105)	2.588** (1.306)	1.612 (1.347)	0.507 (1.320)
Projected Unemployment Gap, $(u - u^*)_t$	−1.192*** (0.275)	−1.268** (0.597)	−1.908*** (0.420)	−1.991*** (0.462)	−1.267** (0.627)	−1.012* (0.573)	−0.871 (0.591)
$\times \left(Hawk_t - \overline{Hawk}\right)$	−0.168 (0.198)	−0.621* (0.338)	−0.541 (0.430)	−0.109 (0.615)	−0.074 (0.716)	−0.495 (0.746)	−0.345 (0.808)
$\left(Hawk_t - \overline{Hawk}\right)$	−1.797*** (0.684)	−3.636** (1.477)	−4.432*** (1.431)	−6.435** (2.614)	−3.606 (3.186)	−1.688 (3.162)	0.305 (2.740)
$(r - r^*)_{t-1}$	1.005*** (0.112)	0.485*** (0.176)	0.485** (0.208)	−0.056 (0.232)	0.043 (0.184)	−0.355* (0.186)	−0.416** (0.177)
$(r - r^*)_{t-2}$	−0.169 (0.175)	0.146 (0.202)	0.101 (0.212)	0.466*** (0.166)	0.261 (0.210)	0.198** (0.085)	0.088 (0.229)
$(r - r^*)_{t-3}$	0.147 (0.207)	0.411** (0.180)	0.024 (0.146)	0.273* (0.162)	−0.186 (0.199)	−0.071	−0.186 (0.161)
$(r - r^*)_{t-4}$	0.054 (0.099)	−0.113 (0.160)	0.168 (0.216)	−0.030 (0.259)	0.171 (0.291)	0.195 (0.311)	0.208 (0.281)
$\Delta Deflator^e_{t-1}$	0.038 (0.204)	0.157 (0.196)	−0.116 (0.215)	0.030 (0.240)	−0.367 (0.377)	−0.019 (0.252)	−0.0005 (0.334)
$\Delta Deflator^e_{t-2}$	−0.138 (0.157)	−0.160 (0.367)	−0.052 (0.221)	−0.155 (0.256)	0.042 (0.311)	0.107 (0.216)	0.323** (0.161)
$\Delta Deflator^e_{t-3}$	0.109 (0.207)	−0.410 (0.262)	−0.237 (0.277)	−0.814** (0.358)	−0.337 (0.306)	−0.176 (0.262)	0.150 (0.104)
$\Delta Deflator^e_{t-4}$	−0.346** (0.138)	−0.143 (0.247)	−0.357 (0.413)	−0.112 (0.419)	0.194 (0.371)	0.708** (0.344)	0.917*** (0.354)
$(u - u^*)_{t-1}$	1.220*** (0.390)	0.244 (0.799)	1.011** (0.441)	0.763 (0.639)	0.088 (1.096)	−0.269 (1.009)	−0.244 (0.780)
$(u - u^*)_{t-2}$	0.057 (0.440)	0.248 (0.178)	−0.074 (0.320)	0.589 (0.572)	0.779 (0.882)	0.289 (0.569)	0.029 (0.491)
$(u - u^*)_{t-3}$	−0.615 (0.465)	0.474 (0.320)	0.963* (0.510)	0.847 (0.722)	0.088 (0.728)	0.190 (0.523)	0.180 (0.620)
$(u - u^*)_{t-4}$	0.333 (0.253)	−0.138 (0.298)	−0.448 (0.569)	−0.626 (0.676)	0.045 (0.582)	0.396 (0.484)	0.558 (0.597)
Constant	0.082 (0.196)	−0.111 (0.555)	0.051 (0.656)	0.663 (0.968)	−0.095 (1.074)	−1.352 (1.174)	−2.355** (1.090)
Observations	200	200	200	200	200	198	196
R^2	0.960	0.848	0.768	0.650	0.606	0.609	0.634
Adjusted R^2	0.956	0.833	0.746	0.618	0.569	0.572	0.600
Residual Std. Error	0.741	1.438	1.775	2.183	2.332	2.331	2.265
Wu-Hausman F	2.268*	6.267***	6.322***	16.09***	9.765***	5.584***	2.04

Notes: This table reports the estimates of all of the coefficient in model in eq. (2) on page 3 with projected inflation measured as a projected change in GDP deflator and projected output gap is measured by projected unemployment gap. The Andrews (1991) HAC standard errors are in parenthesis. Weak Instrument statistics (for $h = 0$) are HAWK: 64.8; interaction with deflator inflation: 64.2, interaction with unemployment gap: 79.5. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table B.4. First-Stage of the Long Specification of LP Model (2)

	Dependent variable:		
	$\left(Hawk_t - \overline{Hawk}\right)$	$\times\Delta Deflator_t^e$	$\times(u-u^*)_t$
	(1)	(2)	(3)
Expected Deflator Inflation, $\Delta Deflator_t^e$	−0.008 (0.031)	−0.024 (0.080)	−0.053 (0.047)
$\times\left(Hawk_t^{IV} - \overline{Hawk}^{IV}\right)$	−0.081*** (0.020)	0.169*** (0.053)	−0.010 (0.031)
$(u-u^*)_t$	−0.027 (0.046)	−0.091 (0.120)	−0.089 (0.070)
$\times\left(Hawk_t^{IV} - \overline{HAWK}^{IV}\right)$	−0.094*** (0.021)	−0.160*** (0.054)	0.481*** (0.031)
$\left(Hawk_t^{IV} - \overline{Hawk}^{IV}\right)$	0.703*** (0.067)	0.785*** (0.174)	−0.023 (0.101)
$(r-r^*)_{t-1}$	−0.007 (0.019)	−0.040 (0.048)	−0.039 (0.028)
$(r-r^*)_{t-2}$	−0.017 (0.027)	−0.077 (0.069)	0.007 (0.040)
$(r-r^*)_{t-3}$	0.008 (0.027)	0.023 (0.069)	0.013 (0.040)
$(r-r^*)_{t-4}$	0.040** (0.018)	0.041 (0.048)	0.042 (0.028)
$\Delta Deflator_{t-1}^e$	−0.006 (0.043)	−0.006 (0.112)	−0.022 (0.065)
$\Delta Deflator_{t-2}^e$	0.026 (0.043)	0.084 (0.111)	0.021 (0.064)
$\Delta Deflator_{t-3}^e$	−0.002 (0.043)	0.075 (0.112)	0.002 (0.065)
$\Delta Deflator_{t-4}^e$	0.059* (0.032)	0.271*** (0.084)	0.115** (0.049)
$(u-u^*)_{t-1}$	−0.019 (0.083)	0.070 (0.214)	0.045 (0.124)
$(u-u^*)_{t-2}$	−0.074 (0.088)	−0.257 (0.228)	−0.082 (0.133)
$(u-u^*)_{t-3}$	0.039 (0.085)	0.055 (0.220)	0.076 (0.128)
$(u-u^*)_{t-4}$	0.003 (0.050)	0.102 (0.130)	−0.072 (0.076)
Constant	−0.214*** (0.035)	−0.789*** (0.091)	−0.249*** (0.053)
Observations	200	200	200
R^2	0.744	0.830	0.795
Adjusted R^2	0.720	0.814	0.776
Residual Std. Error	0.191	0.493	0.287
F Statistic	31.172***	52.315***	41.549***
Weak Instrument F	64.791	64.147	79.475

Notes: This table presents the first stage of LP-IV model estimation in eq. (2) on page 3 with projected inflation measured as a projected change in GDP deflator and projected output gap is measured by projected unemployment gap. The Andrews (1991) HAC standard errors are in parenthesis. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.