Systematic Monetary Policy Approach to Taylor Rule

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Abstract

This work estimates the time-varying Taylor rule using FOMC members' preferences. I show that the dovish FOMC board delays policy rate hikes in response to increase in inflation projection. The effect is less pronounced for changes in output gap.

Keywords: Systematic Monetary Policy, Taylor Rule, FOMC

JEL Codes: E21, E52, E12

1 Introduction

The conduct of monetary policy can be divided via two axis (see table 1), 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 1 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.

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

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

1.1 Related literature

Carvalho et al. (2021) argues 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).

Aguiar-Conraria et al. (2018)

This work contribute to. Additionally we this work is one of the first, that uses newly developed way of identification of systematic monetary policy by , which allows us to estimate the aforementioned overall effect of the monetary shock, without controlling for any income related covariates – without possible .

The remainder of 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 conclude.

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 (Jorda, 2005; Plagborg-Møller and Wolf, 2021)

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

where $h = 0, \dots, H$ 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.[1] π_t^e is the measure of the FED expectation of future inflation. I use the average of the one- and two-quarters tealbook inflation forecast 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

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

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,[2] The proposed solution is to instrument $\left(Hawk_t - \overline{Hawk}\right)$ with the index of preferences of the rotating part of FOMC board[3] 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.[4] 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] 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.

[3] 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.

[4] 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.

2.2 Endogeneity Bias

Note that, ideally, in order to estimate eq. (2) on page 2 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

At the same time Carvalho et al. (2021) argues that because the monetary policy shocks tend to explain a small fraction[5] 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 Results

3.1 Response of Monetary Policy to Projected Inflation and Output gap

3.1.1 Short Specification

The estimated coefficients of interest of the short regression can be found in fig. 1 and table 2 on the following page and on page 6. 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 $Hawk_t$. The coefficients (without scaling) for for the main regressors of interest can be seen in table 2 on page 6.

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 .

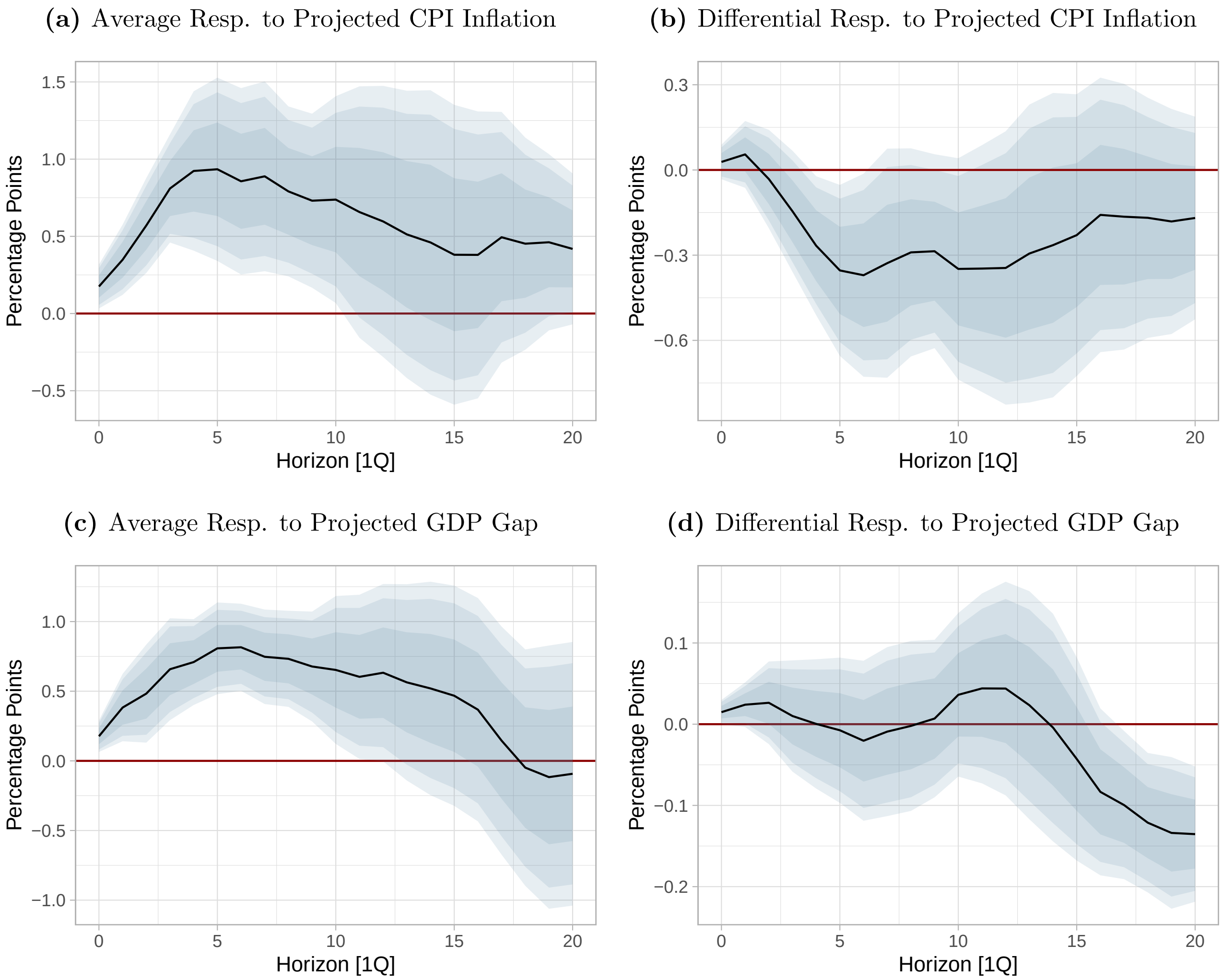
The impact of hawkishness of FOMC on the effect of a change in projected inflation becomes prominent after 3rd quarter and is negative. If the 2 FOMC members out of 12 were changed for hawkish FRB heads, it would reduce the response to inflation by 0.266 percentage in the T+3rd quarter, and the effect 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 responce 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 (measured by *Hawk* index) does decrease both the

[5] 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.

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



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.

Table 2. 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)
Expected 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)
Expected 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	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 2 with projected inflation measured as a projected change in CPI. The Andrews (1991) HAC standard errors are in parenthesis. All of the coefficients can be seen in table B.1 on page 13. 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 is a 2SLS test for endogeneity, p-value is in brackets below. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

3.1.2 Long Specification

The main Taylor Rule coefficients of interest can be found in table 3 on page 8 and impulse responses can be found in fig. 2 on the following page. Note that, in order to look similar to the short specification, the IRFs of deviation of rate from its natural level, $r - r^*$, are calculated with for a shock of decrease in unemployment gap.

The

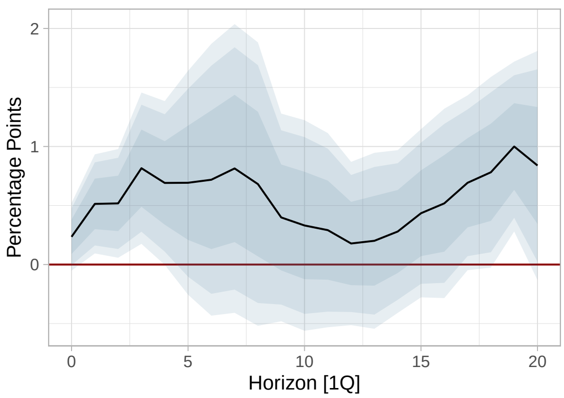
Hack et al. (2023) (in appendix named "Validation Exercise") estimates the model similar to eq. (2) on page 2 under long specification, but under assumption that the systematic monetary policy responds only to inflation. My estimates in fig. 2 on the following page and table 3 on page 8 average and differential 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.

3.1.3 Endogeneity Test

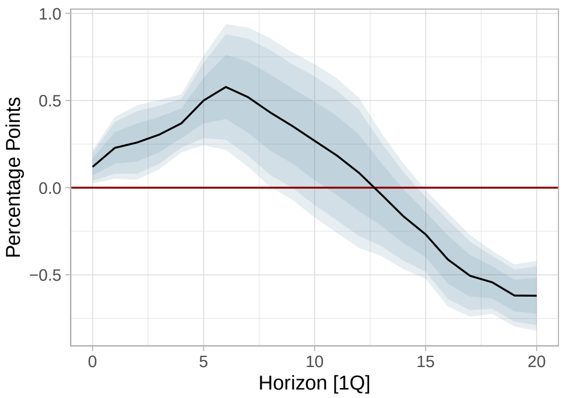
To test the endogeneity (the fact that 3 instruments change the coefficients on variables of interest) I calculate Wu-Hausman statistic (see fig. 3b on the next page for the statistic for each horizon). We can reject the null of equivalence of LP and LP-IV for short specification starting from $h = 8$ 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

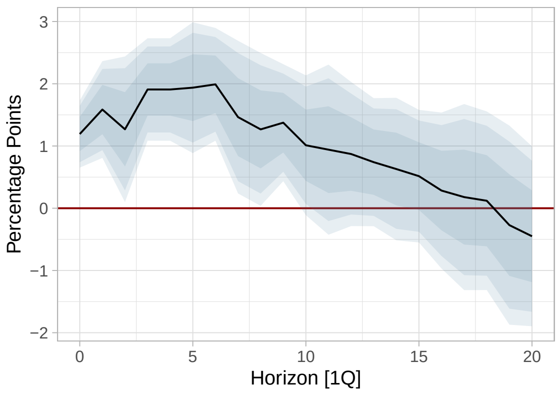
(a) Average Resp. to Deflator Inflation



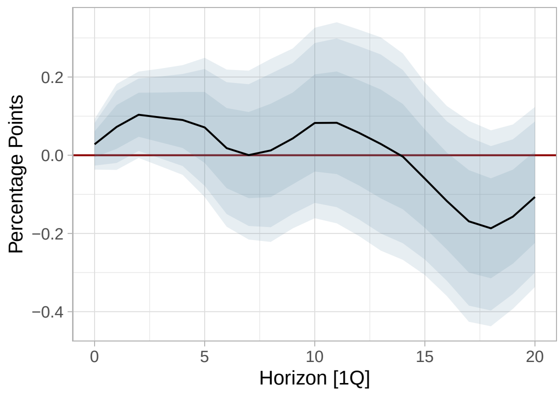
(b) Differential Resp. to Deflator Inflation



(c) Average Resp. to ↓ in Unemployment Gap



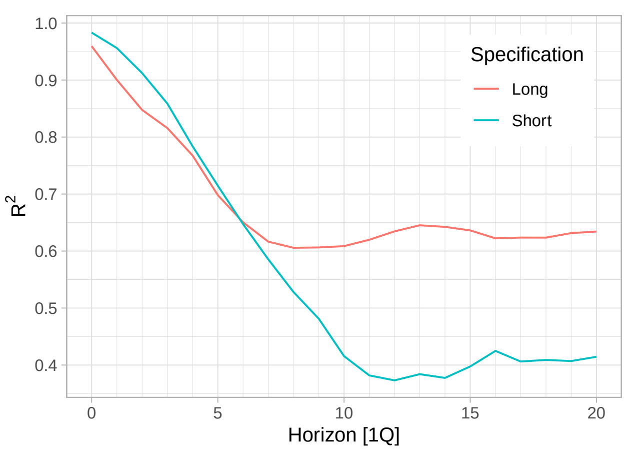
(d) Differential Resp. to ↓ in Unemployment Gap



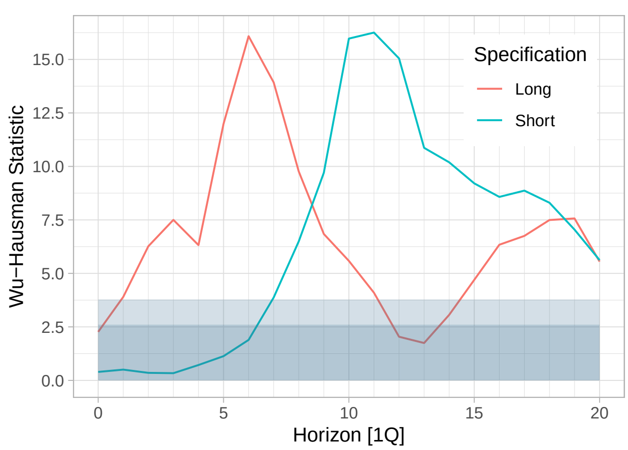
Notes: This figure reports the responses of the $(r - r^*)_t$ to an increase in the Tealbook deflator inflation forecast and *decrease* unemployment gap forecast of 1 p.p. The subfigure 2a reports the response of $(r - r^*)_t$ to projected deflator inflation for the *HAWK* index equal to the sample average; 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.

Figure 3. Additional Statistics for LP Models

(a) In-sample Predictive Ability (R^2)



(b) Wu-Hausman F-Statistic



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

Table 3. 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)
Expected Deflator	0.235	0.518^{**}	0.691^{*}	0.718	0.681	0.331	0.178
Inflation, $\Delta Deflator^e_t$	(0.235)	(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
	(0.654)	(0.654)	(0.510)	(1.105)	(1.306)	(1.347)	(1.320)
Expected Unemployment	-1.192^{**}	-1.268^{**}	-1.908^{***}	-1.991^{***}	-1.267^{**}	-1.012^{*}	-0.871
Gap, $(u - u^*)^e_t$	(0.597)	(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
	(0.338)	(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	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 2 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 is a 2SLS test for endogeneity, p-value is in brackets below. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

3.2 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 2 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.[6] The R^2 for $h = 0$ is 0.98 and 0.96 for short and long specifications respectively. And it remains larger than 0.8 for the 3 quarters after the monetary policy decision. The 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.

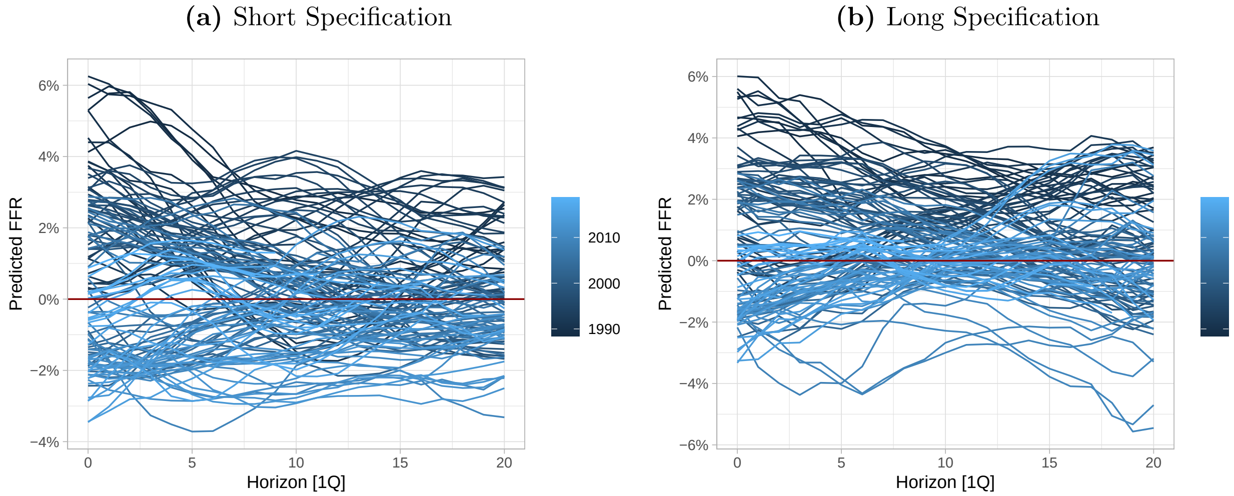
3.3 Historical Estimates of Size and Persistence

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, I assume that in 3

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

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



Notes: This figure shows the eq. (2) on page 2 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.

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.[7] The persistence is calculated by fitting the model

$$(r - r^*)_t = \exp(\mu t)\,(r - r^*)_0 \exp(\varepsilon_t),$$

and persistence is then equal to $\exp(\mu)$. Note that it can be rewritten as

$$\log\left(\frac{(r - r^*)_t}{(r - r^*)_0}\right) = \mu t + \varepsilon_t,$$

which can be estimated with OLS. Note that in HANK model by Kaplan et al. (2018) the μ was assumed to be negative

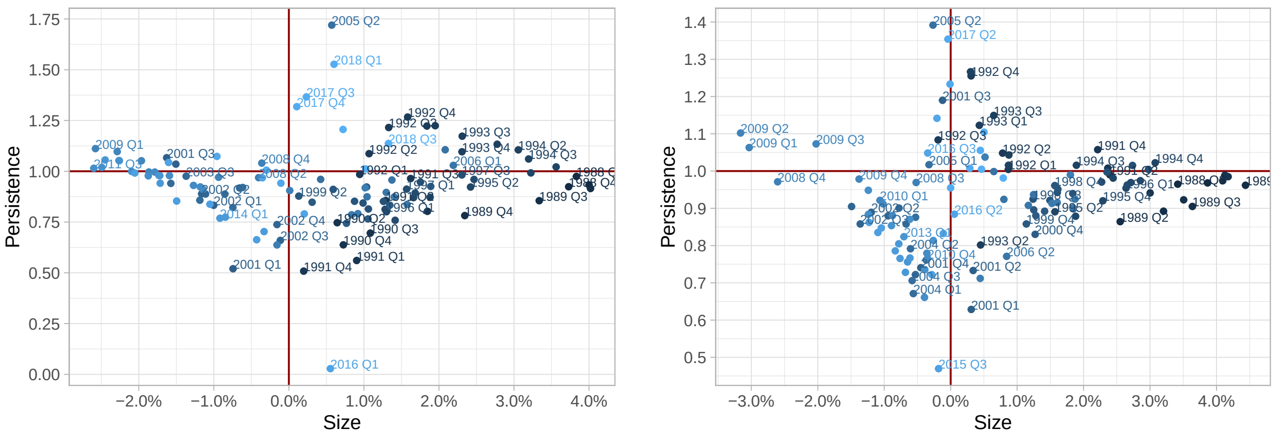
You can find the estimates of size and persistence in fig. 5 on the next page. If size is greater than 0 then the model in eq. (2) on page 2 predicts the contractionary monetary policy, and vice versa. If persistence is larger than 1 then the model predicts the increase in rate for future horizons. Most of the quarter-points (about 71% for short and 75% for long specifications, see table 4 on the next page) are have persistence below 1, that is in most states the estimated model predicted a rate path to be a decline in rates.

We can see 2 clusters of points that can be roughly divided by the year 2000. Since 2000 the monetary policy paths have a reduced size and a larger variation in persistence, which correlates with decrease in hawkishness of FOMC.

[7]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 $1/(T+1)$.

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 3.3 on page 8 for 2 specifications for period from 1988 Q3 to 2018 Q4 (the period of estimation of short specification).

Table 4. Shares of Periods for Different Size and Persistence Quadrants

	Size < 0	Size > 0
Persistence > 1	11.47% 9.02%	16.39% 15.57%
Persistence < 1	29.50% 34.42%	41.80% 40.98%

Notes: Shares of size and persistence estimates for short and long specifications (short specification above, long – below) for period from 1988 Q3 to 2018 Q4 in different quadrants of size-persistence plane.

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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.

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.

B Appendix. Regression Tables

Table B.1. Estimates of Short 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)
Expected 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)	(1.473)
Expected 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)
$\times \left(HAWK - \overline{HAWK}\right)_t$	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_{t-1}^e	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_{t-2}^e	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_{t-3}^e	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_{t-4}^e	−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_{t-1}^e	−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_{t-2}^e	−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_{t-3}^e	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_{t-4}^e	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	0.395	0.352	0.718	1.891	6.496***	15.97***	15.05***

Notes: This table reports the estimates of the coefficients of interest in model in eq. (2) on page 2 with projected inflation measured as a projected change in CPI. 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 LP Model

	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: 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)
Expected Deflator Inflation,	0.235	0.518**	0.691*	0.718	0.681	0.331	0.178
$\Delta Deflator^e_t$	(0.235)	(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
	(0.654)	(0.654)	(0.510)	(1.105)	(1.306)	(1.347)	(1.320)
Expected Unemployment Gap,	−1.192**	−1.268**	−1.908***	−1.991***	−1.267**	−1.012*	−0.871
$(u - u^*)_t$	(0.597)	(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
	(0.338)	(0.338)	(0.430)	(0.615)	(0.716)	(0.746)	(0.808)
$\left(Hawk_t - \overline{Hawk}\right)$	−1.797	−3.636**	−4.432***	−6.435**	−3.606	−1.688	0.305
	(1.477)	(1.477)	(1.431)	(2.614)	(3.186)	(3.162)	(2.740)
$(r - r^*)_{t-1}$	1.005***	0.485***	0.485**	−0.056	0.043	−0.355*	−0.416**
	(0.176)	(0.176)	(0.208)	(0.232)	(0.184)	(0.186)	(0.177)
$(r - r^*)_{t-2}$	−0.169	0.146	0.101	0.466***	0.261	0.198**	0.088
	(0.202)	(0.202)	(0.212)	(0.166)	(0.210)	(0.085)	(0.229)
$(r - r^*)_{t-3}$	0.147	0.411**	0.024	0.273*	−0.186	−0.071	−0.186
	(0.180)	(0.180)	(0.146)	(0.162)	(0.199)		(0.161)
$(r - r^*)_{t-4}$	0.054	−0.113	0.168	−0.030	0.171	0.195	0.208
	(0.160)	(0.160)	(0.216)	(0.259)	(0.291)	(0.311)	(0.281)
$\Delta Deflator^e_{t-1}$	0.038	0.157	−0.116	0.030	−0.367	−0.019	−0.0005
	(0.196)	(0.196)	(0.215)	(0.240)	(0.377)	(0.252)	(0.334)
$\Delta Deflator^e_{t-2}$	−0.138	−0.160	−0.052	−0.155	0.042	0.107	0.323**
	(0.367)	(0.367)	(0.221)	(0.256)	(0.311)	(0.216)	(0.161)
$\Delta Deflator^e_{t-3}$	0.109	−0.410	−0.237	−0.814**	−0.337	−0.176	0.150
	(0.262)	(0.262)	(0.277)	(0.358)	(0.306)	(0.262)	(0.104)
$\Delta Deflator^e_{t-4}$	−0.346	−0.143	−0.357	−0.112	0.194	0.708**	0.917***
	(0.247)	(0.247)	(0.413)	(0.419)	(0.371)	(0.344)	(0.354)
$(u - u^*)_{t-1}$	1.220	0.244	1.011**	0.763	0.088	−0.269	−0.244
	(0.799)	(0.799)	(0.441)	(0.639)	(1.096)	(1.009)	(0.780)
$(u - u^*)_{t-2}$	0.057	0.248	−0.074	0.589	0.779	0.289	0.029
	(0.178)	(0.178)	(0.320)	(0.572)	(0.882)	(0.569)	(0.491)
$(u - u^*)_{t-3}$	−0.615*	0.474	0.963*	0.847	0.088	0.190	0.180
	(0.320)	(0.320)	(0.510)	(0.722)	(0.728)	(0.523)	(0.620)
$(u - u^*)_{t-4}$	0.333	−0.138	−0.448	−0.626	0.045	0.396	0.558
	(0.298)	(0.298)	(0.569)	(0.676)	(0.582)	(0.484)	(0.597)
Constant	0.082	−0.111	0.051	0.663	−0.095	−1.352	−2.355**
	(0.555)	(0.555)	(0.656)	(0.968)	(1.074)	(1.174)	(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	2.268*	6.267***	6.322***	16.09***	9.765***	5.584***	2.04

Notes: 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 LP Model

	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: The Andrews (1991) HAC standard errors are in parenthesis. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.