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Identification of systematic monetary policy

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Abstract

We propose a novel identification design to estimate the causal effects of systematic monetary policy on the propagation of macroeconomic shocks. The design combines (i) a time-varying measure of systematic monetary policy based on the historical composition of hawks and doves in the Federal Open Market Committee (FOMC) with (ii) an instrument that leverages the mechanical FOMC rotation of voting rights. We apply our design to study the effects of government spending shocks. We find fiscal multipliers between two and three when the FOMC is dovish and below zero when it is hawkish. Narrative evidence from historical FOMC records corroborates our findings.

Keywords: monetary policy, FOMC, rotation, government spending.
JEL Codes: E32, E52, E62, E63, H56.

Non-technical summary

Monetary policy decisions made by central banks are intentional responses to macroeconomic conditions. These responses are known as systematic monetary policy. In theory, systematic monetary policy plays a crucial role in influencing the impact of macroeconomic shocks. However, there is a lack of reduced-form empirical evidence that identifies and quantifies this causal relationship. In this study, we first introduce an identification design to assess the causal effects of systematic monetary policy on the propagation of macroeconomic shocks. We then use this design to study the interaction between government spending and the response of systematic monetary policy. Our findings show that systematic monetary policy is a crucial determinant of the effectiveness of fiscal policy.

Our identification design combines a measure of systematic monetary policy based on the historical composition of hawks and doves in the Federal Reserve's Federal Open Market Committee (FOMC) since the 1960s, along with an instrument that levers the mechanical rotation of voting rights in the FOMC. The classification of FOMC members as hawks or doves is based on narratives from news archives, portraying them as either more concerned about inflation (hawks) or more concerned about supporting employment and growth (doves), as in Istrefi (2019).

To account for changes in the composition of hawks and doves in the FOMC that are influenced by economic and political developments, we construct an instrumental variable that takes advantage of the mechanical rotation of voting rights in the FOMC. This rotation is a yearly process that redistributes voting rights among the Federal Reserve Bank presidents. The mechanical nature of the rotation renders it exogenous to economic or political factors, allowing us to identify the causal effects of systematic monetary policy. To the best of our knowledge, our FOMC rotation instrument is the first instrument of systematic monetary policy.

To estimate the causal effects of systematic monetary policy on the propagation of fiscal shocks in the economy, we use a local projection model where macroeconomic variables such as GDP or government consumption respond to the fiscal shock, the interaction between the fiscal shock and the Hawk-Dove balance in the FOMC, the level of the Hawk-Dove balance, and potentially other factors as well. The instrument vector is given by the vector of regressors when replacing the Hawk-Dove balance with the FOMC rotation instrument. For the fiscal shock, we examine military spending shocks as studied in previous works by Ramey (2011) and Ramey and Zubairy (2018), for the period from 1960 to 2014.

Our findings show that the response of GDP to government spending shocks depends crucially on the number of dovish and hawkish FOMC members. An increase in discretionary government spending leads to a GDP expansion which is more pronounced when more dovish FOMC members vote in the FOMC. Conversely, more hawks dampen the expansionary effect of government spending. Quantitatively, we find that the peak GDP increase roughly doubles when there are two more doves in the FOMC relative to the long-run sample average. In contrast, we find that GDP does not expand in response to additional government spending when there are two more hawks in the FOMC.

A common metric to evaluate the effectiveness of fiscal spending is the fiscal multiplier: the increase in GDP per additional government spending. We find a strong and highly significant dependence of the fiscal multiplier on systematic monetary policy. Under a hawkish FOMC, the multiplier is insignificant, with point estimates at or below 0. Under a dovish FOMC, the multiplier is highly statistically significant and ranges between 2 and 3. An additional important result is that when we consider systematic monetary policy in our analysis, the average multipliers are larger and more precisely estimated compared to a linear model that ignores this relationship.

Upon examining the mechanism underlying the state-dependent effects of government spending shocks, we observe distinct patterns in nominal interest rates depending on the hawkishness of the FOMC. Under a hawkish FOMC, nominal interest rates tend to rise substantially. On the other hand, under a dovish FOMC, nominal interest rates initially decline and experience a delayed increase. This suggests that a hawkish FOMC hikes rates in response to fiscal expansion to contain inflationary pressures. Indeed, we find that a hawkish FOMC is more successful in containing inflation expectations and inflation.

It is important to note that drawing the conclusion that the government should increase spending when central banks have committees with dovish members in the majority could be misleading. This is because such changes in government spending would not be random shocks (what we studied) but predictable policy decisions. The Lucas critique applies if there are structural changes in the conduct of fiscal policy. To avoid misleading conclusions, a promising direction for future research is to utilize our findings to inform micro-founded models that study optimal fiscal stabilization policies.

Finally, while our identification design is specific to U.S. monetary policy, a promising avenue for future research is to study other countries or currency areas in which committees decide monetary policy. In fact, since 2015 the European Central Bank's Governing Council allocates voting rights to its members through a rotation mechanism. Investigating these contexts can provide valuable insights into the interaction between systematic monetary policy and fiscal shocks in different settings.

1 Introduction

Monetary policy is not random but a purposeful response to macroeconomic conditions. This response represents systematic monetary policy. Fundamentally, the systematic response reflects the preferences of the policymakers, e.g., concerning price stability and employment, which change over time as the policymakers change. As a consequence, the effects of macroeconomic shocks differ across time, depending on systematic monetary policy. In theory, systematic monetary policy is well-known to be important for the propagation of macroeconomic shocks. However, there is no direct evidence on the causal effects of the Fed's systematic monetary policy.[1]

The main contribution of this paper is an identification design to estimate the causal effects of systematic monetary policy on the propagation of macroeconomic shocks. We use historical fluctuations in the composition of hawks and doves in the Federal Open Market Committee (FOMC) to measure time variation in systematic monetary policy. To address the concern that these fluctuations are endogenous to economic and political developments, we propose an instrument that exploits the mechanical rotation of voting rights in the FOMC. To the best of our knowledge, our FOMC rotation instrument is the first instrument for systematic monetary policy. We then apply the identification design to government spending shocks and find that fiscal multipliers significantly depend on systematic monetary policy. When the FOMC is dovish, it delays tightening in response to an expansionary fiscal spending shock, and fiscal multipliers are between two and three. Conversely, multipliers can be negative under a hawkish FOMC that tightens faster and more aggressively.

We measure time variation in systematic U.S. monetary policy building on the narrative classification of FOMC members by Istrefi (2019) which uses news archives to classify members of the FOMC as hawks and doves, for the period 1960 to 2023. Hawks are more concerned about inflation, while doves are more concerned about supporting employment and growth. Following Istrefi (2019) and Bordo and Istrefi (2023), we aggregate individual FOMC member preferences into an aggregate Hawk-Dove balance for each FOMC meeting.[2] The Hawk-Dove balance is an appealing measure of systematic monetary policy because it reflects the aggressiveness of the FOMC towards fulfilling one or the other leg of the dual mandate without having to specify a policy reaction function or the policy tools.

Identifying the causal effects of systematic monetary policy, independent of how it is measured, is challenging because of endogeneity. For example, systematic monetary policy may change in response to unemployment or inflation (Davig and Leeper, 2008). Similarly, the appointment of central bankers can depend on economic and political circumstances, e.g., as documented

[1] A vast empirical literature estimates the effects of monetary policy shocks (e.g., the pioneering work by Romer and Romer, 1989; Bernanke and Blinder, 1992; Cochrane and Piazzesi, 2002). These shocks are commonly understood as deviations from a policy rule, whereas most policy variation is due to systematic monetary policy, i.e., the rule itself. While evidence on monetary policy shocks may (indirectly) be informative about the effects of systematic monetary policy under certain assumptions (e.g., McKay and Wolf, 2022), we propose to directly estimate the causal effects of systematic monetary policy.

[2] Istrefi (2019) constructs the FOMC Hawk-Dove balance and shows that these preferences match with narratives on monetary policy, preferred interest rates, dissents, and forecasts of FOMC members. Bordo and Istrefi (2023) study what forms these preferences and how the FOMC composition affects decision making by estimating a Taylor rule augmented by the Hawk-Dove balance. We go beyond their analysis by estimating the dynamic causal effects of systematic monetary policy on the propagation of macroeconomic shocks.

for the Nixon administration (Abrams, 2006; Abrams and Butkiewicz, 2012). We discuss this identification challenge through the lens of a New Keynesian model in which the coefficients of the monetary policy rule fluctuate in response to macroeconomic shocks. The model dynamics can be represented as a state-dependent local projection. The OLS estimates of the local projection will fail to identify the causal effects of systematic monetary policy because they are contaminated by unobserved shocks that change the monetary policy rule. Instead, we show that an instrument that captures exogenous variation in systematic monetary policy achieves identification.

We propose an instrument that levers exogenous variation in the Hawk-Dove balance arising from the FOMC rotation. The rotation is an annual mechanical scheme that shuffles four voting rights among eleven Federal Reserve Bank presidents.[3] Specifically, our FOMC rotation instrument is the Hawk-Dove balance of the subset of FOMC members with temporary voting rights through the rotation. Importantly, the mechanic nature of the rotation renders it orthogonal to economic and political developments.

Our identification design combines the measure of systematic monetary policy and the instrument in a state-dependent local projection for a macroeconomic shock of interest. Specifically, we regress an outcome of interest on the shock, the shock interacted with the Hawk-Dove balance, the Hawk-Dove balance in levels, and possibly further controls. The instrument vector is given by the vector of regressors when replacing the Hawk-Dove balance with the FOMC rotation instrument. This local projection is in line with the dynamics of a New Keynesian model with time-varying systematic monetary policy. However, different from a New Keynesian model, our design identifies the effects of systematic monetary policy without imposing strong structural assumptions.

We apply our identification design to study the effects of government spending shocks. The response of monetary policy to fiscal policy is widely considered to be crucial for the effectiveness of fiscal policy, both in the policy debate (e.g., Blinder, 2022) and in New Keynesian theory (e.g., Woodford, 2011; Farhi and Werning, 2016). Notwithstanding the perceived importance of this type of fiscal-monetary interaction, there is no direct evidence on the causal effects of the Fed's systematic monetary policy for the propagation of government spending shocks.

We focus on the military spending shocks in Ramey (2011) and Ramey and Zubairy (2018) for the period 1960-2014.[4] We find that the real GDP response significantly depends on systematic monetary policy. The GDP response increases in the share of dovish FOMC members, and decreases in the share of hawks. When the Hawk-Dove balance exceeds the sample average by two doves, quarterly GDP increases by up to 0.7% in response to a military shock, which is expected to raise cumulative military spending by 1% of GDP over the next five years. Conversely, quarterly GDP falls by up to 0.3% when the Hawk-Dove balance exceeds the sample average by two hawks.[5]

[3] The rotation is considered important by Fed watchers in the media. Each year before the rotation, they discuss its implications for the direction of monetary policy. Relatedly, Ehrmann et al. (2022) study how voting rights affect the communication of Federal Reserve Bank presidents and market reaction to this communication.

[4] In the post-Korean War sample that we study, Ramey (2011) shows that these shocks are poor instruments and the average spending multiplier is imprecisely estimated. In contrast, we show that accounting for time-varying systematic monetary policy strongly improves the precision of the estimated multiplier.

[5] For comparison, an increase of the Hawk-Dove balance by two doves or two hawks roughly corresponds to

The negative (and significant) dependence of the GDP response on the FOMC's Hawk-Dove balance is in line with commonly used New Keynesian models in which a more aggressive central bank response to fiscal shocks leads to smaller GDP effects. We see this evidence as supporting the usefulness of our identification design. In contrast, the OLS estimate substantially underestimates the role of systematic monetary policy on the GDP response to spending shocks.

A common metric to assess the effectiveness of fiscal spending is the spending multiplier, the dollar increase of real GDP per additional dollar of real government spending. We estimate the two- and four-year cumulative spending multipliers and find strong dependence on systematic monetary policy. While multipliers under a hawkish FOMC are typically insignificant with point estimates at or below 0, we find that dovish multipliers are between 2 and 3 and statistically significant. Moreover, the average multipliers are larger and much more precisely estimated when accounting for systematic monetary policy compared to a linear model that omits this state dependency. These results are robust to various modeling choices, as we show in an extensive sensitivity analysis.

We further inspect the mechanism behind the state-dependent effects of government spending shocks. We show that nominal interest rates rise under a hawkish FOMC, while they initially fall and rise only with substantial delay under a dovish FOMC. When the Hawk-Dove balance exceeds the sample average by two hawks, the federal funds rate (FFR) starts to increase within one year and rises up to 50 basis points beyond the pre-shock level around two years after the shock. Conversely, the FFR falls below the pre-shock level for more than two years after the shock, and then sharply rises toward a 50 basis point increase three years after the shock, when there are two more doves in the FOMC. The different interest rate responses are consistent with the fiscal multiplier estimates across hawkish and dovish FOMCs. Moreover, we find that hawkish policy is more successful in containing inflation and that the monetary policy response primarily transmits to real GDP through private consumption.

Finally, we complement our quantitative analysis with narrative evidence from the historical records of the FOMC meetings. These records reveal that FOMC members and staff frequently discuss changes in (military) government spending, their potential impact on the economy and inflation, and the FOMC's policy response. We further provide detailed case studies of two important military spending buildup events in the 1960s, associated with the U.S. Space Program and the Vietnam War. We show that a hawkish FOMC indeed tightens faster after military buildups, whereas a dovish FOMC delays action.

Relation to literature. This paper contributes to a literature that aims to identify the effects of systematic monetary policy on the propagation of macroeconomic shocks. Closely related are McKay and Wolf (2022) and Barnichon and Mesters (2022) which differ in the required structural assumptions and observational requirements from our identification design.[6] Their approach assumes a linear (structural) model to identify the effects of monetary policy rules using multiple monetary policy (news) shocks. In contrast, our approach exploits the historical

one standard deviation in the change of the Hawk-Dove balance.

[6] McKay and Wolf (2022) focus on constructing policy counterfactuals, whereas Barnichon and Mesters (2022) uses a similar approach to study optimal policy. Relatedly, Wolf (2023) uses the approach of McKay and Wolf (2022) to provide fiscal policy shock counterfactuals for a strict inflation targeting central bank.

variation in systematic monetary policy in a non-linear model to directly estimate its causal effects. In fact, our evidence shows that the non-linearity with respect to systematic monetary policy is statistically significant and economically large. This suggests that avoiding the linearity assumption is important, underscoring the importance of our identification design. A more traditional approach constructs monetary policy counterfactuals via a sequence of monetary policy shocks (e.g., Bernanke et al., 1997; Kilian and Lewis, 2011; Benati, 2021).[7] Yet, this approach is subject to the Lucas critique (Sargent, 1979), except for the special case of modest shocks (Leeper and Zha, 2003). Our identification design is not subject to this Lucas critique because we explicitly model and estimate how the dynamics depend on systematic monetary policy. Another closely related paper is Cloyne et al. (2021), which estimates the role of systematic monetary policy for the propagation of fiscal consolidation shocks. Whereas Cloyne et al. (2021) leverages time-invariant cross-country differences in systematic monetary policy estimated from Taylor rule regressions, we leverage exogenous variation in systematic monetary policy in the U.S. over time.

Another approach of estimating the effects of time-varying systematic monetary policy uses non-linear VAR models (e.g., Primiceri, 2005; Sims and Zha, 2006). A key advantage of our approach is that it requires weaker identifying assumption and addresses the potential endogeneity of systematic monetary policy. Our paper also relates to a literature studying macroeconomic models with exogenous changes in systematic monetary policy (e.g., Davig and Leeper, 2007; Bianchi, 2013; Leeper et al., 2017) or endogenous changes (e.g., Davig and Leeper, 2008; Barthélemy and Marx, 2017). Our time-series approach requires fewer structural assumptions and provides moments to discipline such models.

Finally, our paper relates to a large empirical literature that estimates the government spending multiplier. Most empirical estimates find an average fiscal spending multiplier between 0.5 and 1.5 (e.g., Blanchard and Perotti, 2002; Mountford and Uhlig, 2009; Barro and Redlick, 2011; Ramey, 2011). Closely related are recent papers which study how the effects of government spending shocks differ at the zero lower bound (e.g., Ramey and Zubairy, 2018; Miyamoto et al., 2018). While the zero lower bound reflects a specific monetary policy regime, this regime is endogenous to the business cycle which means the estimates may reflect both the regime and the shocks leading to it. Instead, we isolate the causal effects of monetary policy. Another related paper is Nakamura and Steinsson (2014), which estimates relative regional multipliers that difference out the response of monetary policy. Our paper also relates to many recent papers that have estimated state-dependencies of the multiplier (other than systematic monetary policy), e.g., depending on the economy being in recession (Auerbach and Gorodnichenko, 2012; Jordà and Taylor, 2016; Ramey and Zubairy, 2018; Ghassibe and Zanetti, 2022); sign of the shock (Barnichon et al., 2022; Ben Zeev et al., 2023); exchange-rate regime, trade openness, and public debt (Ilzetzki et al., 2013); foreign holdings of debt (Broner et al., 2022); and tax progressivity (Ferrière and Navarro, 2018).

The paper is organized as follows: Section 2 provides a simple New Keynesian model to discuss the identification challenge. Section 3 introduces the identification design for system-

[7] A further related paper on the intersection of shocks and systematic policy is Arias et al. (2019) which identifies monetary policy shocks via sign restrictions on systematic monetary policy.

atic U.S. monetary policy. Section 4 contains the main empirical results on the effects of fiscal spending shocks. Section 5 provides evidence for understanding the mechanism. Section 6 provides a narrative of the FOMC records in the 1960s. Section 7 concludes.

2 Identification challenge

In this section, we present a stylized non-linear New Keynesian model in which systematic monetary policy may fluctuate endogenously. We use the model to expound the challenge of empirically identifying the effects of systematic monetary policy on the propagation of macroeconomic shocks.

A New Keynesian model. The model is a textbook New Keynesian model (e.g., Galí, 2015) except for a monetary policy rule with time-varying coefficients. Households choose consumption, labor and bond holdings to maximize $E_0 \sum_{t=0}^{\infty} \beta^t \left(\log C_t - N_t^{1+\varphi} \right)$ subject to budget constraints. Intermediate good firms produce variety goods using $Y_{it} = x_t^a N_{it}$ where x_t^a is exogenous productivity. The price of the variety good can be reset with a constant probability $1-\theta$. Final good firms produce the final good $Y_t = \left(\int_0^1 Y_{it}^{(\epsilon-1)/\epsilon} di \right)^{\epsilon/(\epsilon-1)}$. A fiscal policy authority finances government spending $G_t = \gamma Y x_t^s$ with lump-sum taxes where $\gamma \in [0,1)$, Y is steady-state output, and x_t^s denotes exogenous changes in fiscal spending. Goods market clearing requires $Y_t = C_t + G_t$. The exogenous variables follow stable AR(1) processes $\log x_t^k = \rho_k \log x_{t-1}^k + \varepsilon_t^k$ with $\varepsilon_t^k \sim (0, \sigma_k^2)$ for $k = a, s$ respectively. A monetary policy rule closes the model. Letting lower case letters denote (log) deviations from the steady state, the monetary authority sets nominal interest rates i_t according to

$$i_t = \widetilde{\phi}_t \pi_t, \tag{2.1}$$

where $\widetilde{\phi}_t \in (1, \infty)$ is *systematic monetary policy*, which varies over time according to a stable AR(1) process

$$\phi_t = \rho_\phi \phi_{t-1} + \zeta^s \varepsilon_t^s + \zeta^a \varepsilon_t^a + \eta_t, \tag{2.2}$$

where $\widetilde{\phi}_t = \phi + \phi_t$ and ϕ denotes the unconditional mean of $\widetilde{\phi}_t$. Importantly, we allow systematic monetary policy to be endogenous, as ϕ_t may respond to macroeconomic shocks $(\varepsilon_t^s, \varepsilon_t^a)$.[8] Such endogeneity creates an empirical identification challenge as we discuss toward the end of this section. In addition, we allow for exogenous changes in systematic monetary policy, captured by the exogenous policy shifter η_t. We assume that ε_t^s, ε_t^a, and η_t are mutually independent and identically distributed over time.

Accounting for the non-linear effects of systematic monetary policy ϕ_t, the approximate equilibrium dynamics of GDP are given by

$$y_t = a + b_s x_t^s + b_a x_t^a + c_s x_t^s \phi_t + c_a x_t^a \phi_t + d\phi_t, \tag{2.3}$$

[8] For DSGE models with exogenous changes in the Taylor rule coefficients, see, e.g., Davig and Leeper (2007) and Bianchi (2013). For endogenous changes in the Taylor rule coefficients, see, e.g., Davig and Leeper (2008) and Barthélemy and Marx (2017).

where a, b_s, b_a, c_s, c_a, d are coefficients that depend on the deep structural parameters of the model. Appendix A.1 provides details on the derivation.

Identification challenge. We next discuss the challenge of identifying the effects of systematic monetary policy from a regression when y_t is generated by (2.3). Without loss of generality, and in anticipation of our main empirical question, we focus our discussion on the fiscal spending shock. Consider an econometrician who observes y_t, ε_t^s, ϕ_t, and estimates the state-dependent local projection

$$y_{t+h} = \alpha^h + \beta^h \varepsilon_t^s + \gamma^h \varepsilon_t^s \phi_t + \delta^h \phi_t + v_{t+h}^h, \tag{2.4}$$

for $h = 0, \ldots, H$ forecast horizons. For $h = 0$, the residual v_{t+h}^h contains lagged spending shocks, contemporaneous and lagged technology shocks, and the interaction of these shocks with ϕ_t. For $h > 0$, the residual further contains shocks (ε_t^s, ε_t^a) and policy shifter (η_t) occuring between t and $t + h$. The estimands in (2.4) are

$$\beta^h = b_s(\rho_s)^h \ , \qquad \gamma^h = c_s(\rho_s\rho_\phi)^h \ , \qquad \delta^h = d(\rho_\phi)^h \ . \tag{2.5}$$

Both β^h, the average effect of the spending shock, and γ^h, the differential effect associated with ϕ_t, diminish in the forecast horizon h.

We next ask whether the OLS estimates of $(\beta^h, \gamma^h, \delta^h)$ are consistent, i.e., whether they asymptotically recover the estimands in (2.5).[9] In general, consistency holds under the strong exogeneity assumption $\zeta^s = \zeta^a = 0$, that is if ϕ_t is independent of the macroeconomic shocks. In contrast, if ϕ_t correlates with at least one of the shocks, the OLS estimates do *not* consistently estimate $(\beta^h, \gamma^h, \delta^h)$. If, for example, ϕ_t responds to a technology shock, the OLS estimator will be contaminated by the response of GDP to the technology shock.[10] For further details, see Appendix A.2.

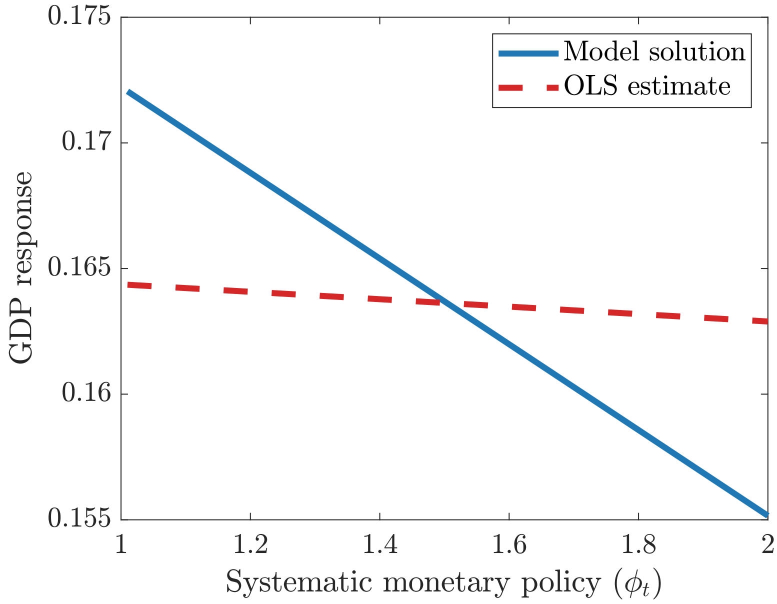
Now suppose the econometrician observes an instrument ϕ_t^{IV} that is correlated with ϕ_t (relevance), but uncorrelated with all past, present, and future macroeconomic shocks ε_t^s and ε_t^a and that is uncorrelated with all past and future policy shifters η_t (exogeneity). Consider the IV estimates of $(\beta^h, \gamma^h, \delta^h)$ when using $(\varepsilon_t^s, \varepsilon_t^s\phi_t^{IV}, \phi_t^{IV})$ as instrument vector for the regressors $(\varepsilon_t^s, \varepsilon_t^s\phi_t, \phi_t)$. The IV estimator consistently estimates $(\beta^h, \gamma^h, \delta^h)$, even when ϕ_t fluctuates endogenously in response to macroeconomic shocks $(\zeta^a, \zeta^m \neq 0)$. For further details, see Appendix A.2. This result guides the remainder of our paper in which we propose an instrument for systematic monetary policy and use it to estimate the causal effects of systematic monetary policy.

Illustration. To illustrate the effects of systematic monetary policy and the identification challenge, we focus on a special case of our economy in which $\rho_s = \rho_a = \rho_\phi = 0$. To understand

[9] We explicitly include δ^h in the vector of coefficients because including the (endogenous) control variable ϕ_t in the regression is important for identification, as ϕ_t is correlated with ε_t^s and $\varepsilon_t^s\phi_t$ in general.

[10] If the econometrician observes and includes *all* shocks and corresponding interaction terms in the regression according to equation (2.3), then the OLS estimates will be consistent without the exogeneity assumption. In practice, this is infeasible as many shocks are (partially) unobserved.

Figure 1: GDP response and systematic monetary policy



Notes: The solid line shows the model solution for the GDP response to a spending shock as a function of systematic monetary policy (ϕ_t), i.e., $b_s + c_s\phi_t$, with b_s and c_s given by (2.6) and the parametrization: $\beta = 0.99$, $\theta = 0.75$, $\epsilon = 9$, $\varphi = 2$, $\gamma = 0.2$, $\bar{\phi} = 1.5$, $\zeta^s = 1$, $\zeta^a = 0.25$, $\sigma_s = \sigma_a = 1$. The dashed line shows the OLS estimate $\hat{\beta}_s^{\text{OLS}} + \hat{\gamma}_s^{\text{OLS}}\phi_t$ based on a regression of (2.3) when the terms in u_t are unobserved. The implied coefficients are $\beta^s = 0.164$ and $\gamma^s = -0.017$, and the large-sample OLS estimates are $\hat{\beta}_s^{\text{OLS}} = 0.164$ and $\hat{\gamma}_s^{\text{OLS}} = -0.002$.

how ϕ_t affects the GDP response to fiscal spending shock ε_t^s, we need to know

$$b_s = \gamma\,(1 + \lambda\phi)\,\omega^{-1}\ , \qquad c_s = -\gamma(1-\gamma)\lambda\varphi\omega^{-2}\ , \tag{2.6}$$

where $\omega = 1 + \lambda\,(\varphi(1-\gamma) + 1)\,\phi$, $\lambda = (1-\theta)(1-\beta\theta)/\theta$. Since $\beta_s > 0$ and $\gamma_s < 0$ (under standard parameter restrictions), the GDP response falls in the strength of the monetary policy reaction to inflation. This is the monetary offset (e.g., Woodford, 2011; Christiano et al., 2011). The solid line in Figure 1 illustrates the monetary offset. The dashed line illustrates the OLS bias in the estimated GDP response to the spending shock. In our example, the OLS estimate understates the role of systematic monetary policy.

3 Identification design

In this section, we propose an identification design to study how systematic monetary policy in the U.S. shapes the propagation of macroeconomic shocks. Our identification design relies on three crucial elements: (i) a measure of systematic monetary policy, (ii) an instrument for systematic monetary policy, and (iii) a state-dependent local projection regression that combines (i) and (ii) to tackle the identification challenge discussed in the preceding section.

3.1 Hawk-Dove balance in the FOMC

In the following, we build on the classification of Federal Open Market Committee (FOMC) members into hawks and doves by Istrefi (2019) and argue that the Hawk-Dove balance captures well variation in systematic monetary policy over time.

The FOMC. The FOMC is the committee of the Federal Reserve that sets U.S. monetary policy. The FOMC consists of 12 members: the seven members of the Board of Governors of the Federal Reserve System, including the Federal Reserve Chair, the president of the Federal Reserve Bank (FRB) of New York, and four of the remaining 11 FRB presidents, who serve one-year terms on a rotating basis. The seven FRB presidents temporarily without FOMC membership participate in the FOMC meetings as non-voters.

Individual policy preferences. To measure the policy preferences of FOMC members we use the Istrefi (2019) classification of FOMC members as hawks and doves, for the period 1960-2023.[11] Underlying this classification are more than 20,000 real-time media articles from over 30 newspapers and business reports of Fed watchers (available in news archives like ProQuest Historical Newspapers and Factiva) mentioning individual FOMC members. Istrefi (2019) uses these articles to categorize individual FOMC members as hawks or doves for each FOMC meeting based on the news information available up until the meeting. So, the Hawk-Dove classification is a panel that tracks FOMC members over time, at FOMC meeting frequency. Hawks are perceived to be more concerned with inflation, while doves are more concerned with employment and growth.[12] Through the lens of our model in Section 2, we can think about hawks as preferring a larger inflation coefficient ϕ_t than doves. However, the Hawk-Dove classification we use is not tied to assuming a specific policy rule.

Overall, 129 of the 147 FOMC members between 1960 and 2023 are classified as hawk or dove. The news coverage for the remaining 18 members does not allow classification (as hawk or dove) for any meeting, as some served in the early 1960s with sparse media coverage and others are very recent appointments in the FOMC. The majority (95) of the classified FOMC members are consistently hawks or doves over time while the rest switches camps at least once. Swings are equally split in either direction and quite uniformly distributed over time. On average, the 34 swinging FOMC members switch camps at only 1.8% of the member-meeting pairs.

While true policy preferences are unobserved, Istrefi (2019) shows that perceived preferences match well with policy tendencies that are unknown in real-time to the public, as expressed by preferred interest rates, with forecasting patterns of individual FOMC members, and with dissents. In addition, Bordo and Istrefi (2023) show that the FOMC members' educational background, e.g., whether they graduated from a university related to the Chicago school of economics, and early life experience, i.e., whether they grew up during the Great Depression, predicts the Hawk-Dove classification. The long lasting effect of the early life experience in the formation of policy preferences is consistent with the very few swings in our sample.

[11] The data in Istrefi (2019) covers 1960 through 2014. The data is currently extended up to the first meeting of 2023. Thus, our sample covers all 634 (scheduled) FOMC meetings between 1960 and 2023.

[12] A typical example of a newspaper quote used to categorize a hawk reads: "Volcker leans toward tight-money policies and high interest rates to retard inflation", New York Times, 2 May 1975. For a dove: "The weakness of Treasury prices and higher yields was seen reflecting the view that Bernanke will be 'pro-growth' and perhaps less hawkish on inflation, said John Roberts, managing director at Barclays Capital in New York", Dow Jones Capital Markets Report, 24 October 2005.

Aggregate Hawk-Dove balance. To measure variation in systematic monetary policy over time, we aggregate the cross-section of individual FOMC member preferences into an aggregate Hawk-Dove balance for each meeting (cf. Istrefi, 2019). We do so because the nature of monetary policy-making by committee involves the aggregation of diverse individual policy preferences in a collective decision.[13] We adopt a symmetric numerical scale for the qualitative Hawk-Dove classification in order to aggregate the preferences. We define $Hawk_{i\tau}$ as the policy preference of FOMC member i at FOMC meeting τ:

$$Hawk_{i\tau} = \begin{cases} +1 & \textit{Consistent hawk} \\ +\frac{1}{2} & \textit{Swinging hawk} \\ 0 & \textit{Preference unknown} \\ -\frac{1}{2} & \textit{Swinging dove} \\ -1 & \textit{Consistent dove} \end{cases} \tag{3.1}$$

A consistent hawk is an FOMC member that has not been categorized as a dove in the past. In contrast, a swinging hawk has been a dove at some point in the past. The definition of a consistent dove and a swinging dove is analogous. We assign a lower weight to swingers as they are often perceived as 'middle-of-the-roaders' with more moderate leanings to the hawkish or dovish side (Istrefi, 2019).[14] Finally, we assign $Hawk_{i\tau} = 0$ when the policy preference of the FOMC member is (yet) unknown.

We next aggregate the individual policy preferences in (3.1). We compute the aggregate Hawk-Dove balance by

$$Hawk_{\tau} = \frac{1}{|\mathcal{M}_{\tau}|} \sum_{i \in \mathcal{M}_{\tau}} Hawk_{i\tau} \tag{3.2}$$

where $\mathcal{M}_{\tau}$ denotes the set of FOMC members at meeting τ. A full FOMC consists of $|\mathcal{M}_{\tau}| = 12$ members but $|\mathcal{M}_{\tau}|$ is occasionally below 12 because of absent members or vacant positions.[15] The Hawk-Dove balance in (3.2) is the arithmetic average across individual preferences. This is our baseline aggregation of the Hawk-Dove balance in the FOMC and conforms well with the consensual mode in which the FOMC typically operates.[16][17] In Section 4.5, we show that our

[13]Relatedly, Blinder (1999) writes: *While serving on the FOMC, I was vividly reminded of a few things all of us probably know about committees: that they laboriously aggregate individual preferences; that they need to be led; that they tend to adopt compromise positions on difficult questions; and–perhaps because of all of the above–that they tend to be inertial.*

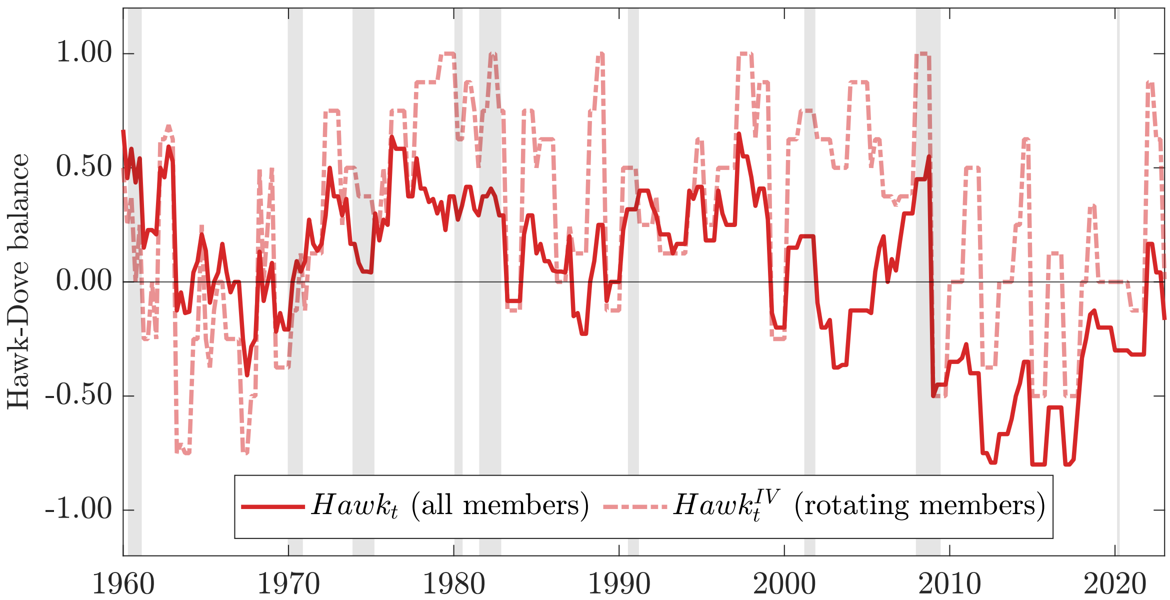
[14]Our empirical findings are robust to not distinguishing between consistent and swinging preferences, see Section 4.5.

[15]When a substitute temporarily replaces an absent FOMC member, we assume the substitute acts in the interest of the original FOMC member and assign the same policy preference, see Appendix B for details. This assumption affects less than one percent of all observations and is not important for our results.

[16]Riboni and Ruge-Murcia (2010) argue that a consensus model fits actual policy decisions of the Federal Reserve. In addition, Riboni and Ruge-Murcia (2022) provide evidence suggesting that policy proposals of the Fed Chair are the result of a compromise, reflecting a balance of power within the FOMC.

[17]Cieslak et al. (2022) construct a Hawk-Dove score based on the language in FOMC meeting transcripts. In contrast to our measure which captures FOMC members preferences about monetary policy, their measure captures (a hawkish or dovish) sentiment on current direction of policy changes. Furthermore, Ferguson et al. (2023) classify central bank governors in 80 countries as hawks and doves, with respect to financial sector support, for the periods preceding banking crises.

Figure 2: Hawk-Dove balance in the FOMC



Notes: The solid red line shows the quarterly time series of the aggregate Hawk-Dove balance of the FOMC ($Hawk_t$) from 1960 until 2023. The dashed red line shows the aggregate Hawk-Dove balance of the subgroup of rotating FRB presidents with voting right in period t, the FOMC rotation instrument ($Hawk_t^{IV}$). Grey bars indicate NBER dated recessions.

empirical findings are robust to alternatively using the median of preferences or putting a higher weight on the Fed Chair's preference. Finally, we aggregate $Hawk_\tau$ from meeting frequency to quarterly frequency. We compute the Hawk-Dove balance $Hawk_t$ for quarter t as the average balance in the first month of the quarter. If the first month is without a meeting, we use the first preceding month with a meeting.

We present the evolution of the Hawk-Dove balance from 1960 to 2023 as the solid line in Figure 2. There is considerable variation in this balance, featuring both hawkish and dovish majorities. The variation reflects the turnover of rotating FOMC members, the turnover of non-rotating FOMC members, and changes in policy preferences of incumbent FOMC members. We discuss the importance of these components for $Hawk_t$ fluctuations in Subsection 3.2.

Systematic monetary policy. The aggregate Hawk-Dove balance $Hawk_t$ represents our measure of systematic U.S. monetary policy. It accounts for the diversity of views within the FOMC on how policy should be adjusted to promote both, price stability and maximum employment. This diversity is usually expressed in FOMC meetings through different forecasts of individual members, through dissents, and in public through speeches. While the Fed's response to macroeconomic shocks is more sophisticated and depends on various economic factors, we argue that our Hawk-Dove balance matches well with narratives of monetary policy in the U.S. (Istrefi, 2019). For example, the dovish leaning of $Hawk_t$ in the mid-1960s coincides with a period of delays and hesitation from the FOMC to take anti-inflationary action (Meltzer, 2005). The hawkish majorities in the 1970s might be surprising given the high inflation rates in this period. Yet it is consistent with monetary policy being misguided by an underestimated natural rate of unemployment (DeLong, 1997; Romer and Romer, 2002) and persistence of inflation (Primiceri, 2006). In particular, Orphanides (2004) argues that for the periods before and after Paul Volcker's appointment in 1979, policy was broadly similar and consistent with a strong reaction to Greenbook inflation forecasts.[18] During the 1980s, the perception of a less hawkish FOMC reflects nominations of dovish Board members by President Reagan. In addition, it is consistent with the imperfect credibility of hawkish policy during the Volcker disinflation, as observed in persistently elevated long-term interest rates (indicative of inflation expectations) in this period (Goodfriend and King, 2005). Overall, this suggests that the Hawk-Dove balance captures important aspects of the Fed's systematic policy-making.

Our approach of measuring systematic policy via $Hawk_t$ has several advantages to alternative approaches such as calibrating or estimating policy rules (e.g., Clarida et al., 2000; Bauer et al., 2022). Importantly, we do not have to specify a particular reaction function, nor do we need to restrict the analysis to specific policy instruments or communication strategies.[19] We further avoid the well-known identification issues that plague the estimation of monetary policy rules (Cochrane, 2011; Carvalho et al., 2021). Independently of the policy tool or policy rule, our measure reflects the aggressiveness of the FOMC towards fulfilling one or the other leg of the dual mandate. In addition, the Hawk-Dove balance reflects public beliefs, in real-time, about monetary policymakers. In contrast, ex-post estimates of systematic monetary policy may inadvertently use ex-post information not available at the time of the policy decision, potentially giving rise to misleading conclusions (Orphanides, 2003).

Comparability over time. A potential concern with the classification of FOMC members into hawks and doves is that the meaning of being a hawk or dove might have changed over time. We argue this is likely no major concern. First, Istrefi (2019) has classified each member as a hawk or dove based on a common and time-invariant definition, that is the policy leaning with regard to the dual mandate of the Fed: maximum employment and stable prices. Second, given that preferences tend to be stable, we would expect many swings whenever the meaning of hawks or doves changes. However, swings in measured preferences are rare suggesting that the meaning of being a hawk or dove is relatively stable over time. Third, the fact that we observe large and persistent fluctuations in $Hawk_t$ is incompatible with the Hawk-Dove classification being a relative ranking, according to which hawks are those FOMC members which are more hawkish than the contemporaneous average policy preference among FOMC members, and analogously for doves. Finally, in a robustness exercise in Section 4, we show that our results are robust to using an alternative Hawk-Dove balance which accounts for potential trends in the meaning of hawks and doves.

Relation to monetary policy shocks. Empirically identified monetary policy shocks are often considered to reflect changes in central bank preferences (Christiano et al., 1999; Ramey,

[18] Moreover, Orphanides (2003) shows that a dovish Taylor rule with a sufficiently large weight on the output gap would have resulted in substantially higher inflation.

[19] For a summary of alternative policy rules that the FOMC consults, see here: https://www.federalreserve.gov/monetarypolicy/policy-rules-and-how-policymakers-use-them.htm. Policy instruments have been changing over our sample, from targeting monetary aggregates to targeting the Fed Funds rate, conducting balance sheets policy, and through forward guidance communication.

2016). Hence, they may be related to the Hawk-Dove balance, our measure of systematic monetary policy. In Appendix D, we characterize this relationship based on the Romer and Romer (2004) identification strategy of monetary policy shocks. Because their identification strategy assumes a time-invariant policy rule, the identified monetary policy shocks may indeed capture time variation in systematic monetary policy. However, the relationship between identified monetary policy shocks and systematic monetary policy is non-linear and also depends on the state of the economy (e.g., the inflation rate). Instead, our Hawk-Dove balance provides a cleaner measure of systematic monetary policy.

3.2 FOMC Rotation Instrument

We next propose and discuss a novel FOMC rotation instrument that allows us to identify the effects of systematic monetary policy, even if monetary policy is endogenous to the state of the economy (cf. Section 2).

Potential endogeneity. Systematic monetary policy may change depending on the state of the economy. For example, the Federal Reserve may become more dovish in response to high unemployment, or more hawkish in response to high inflation (cf. Davig and Leeper, 2007). More fundamentally, some FOMC members may become hawkish or new appointments may increase the number of hawks in the FOMC. Changes in individual policy preferences could be intrinsic responses to changes in the macroeconomic environment. They could also be driven by external pressure from lobbies or the government. Relatedly, Abrams (2006) and Abrams and Butkiewicz (2012) document the influence of the Nixon administration on the FOMC in the period leading up to the 1972 election. In addition, which type of central banker gets appointed may depend on the state of the economy. In this context, note that members of the Board of Governors and the Fed Chair require a nomination from the U.S. President for their first and any subsequent term. This may render both extensive margin and intensive margin changes in the Hawk-Dove balance endogenous.

FOMC rotation instrument. To address the endogeneity of the Hawk-Dove balance we propose an instrument which leverages exogenous variation in $Hawk_t$ that arises from the annual FOMC rotation. Each year, four FOMC memberships rotate among eleven FRB presidents following a mechanical scheme that has been in place since the early 1940s. According to the scheme, some FRB presidents become FOMC members every second year (Cleveland and Chicago) and others every third year (Philadelphia, Richmond, Boston, Dallas, Atlanta, St. Louis, Minneapolis, San Francisco and Kansas City). As the rotation of voting rights is independent of the state of the economy, it induces exogenous variation in $Hawk_t$. To leverage the variation from the FOMC rotation we propose a novel instrument, which we refer to as FOMC rotation instrument. Formally, the instrument is given by

$$Hawk_\tau^{IV} = \frac{1}{|\mathcal{R}_\tau|} \sum_{i \in \mathcal{R}_\tau} Hawk_{i\tau}, \tag{3.3}$$

where $\mathcal{R}_\tau$ denotes the set of rotating FOMC members at FOMC meeting τ. A full set of rotating members consists of $|\mathcal{R}_\tau| = 4$ members.[20] We aggregate the FOMC rotation instrument to quarterly frequency analogously to the Hawk-Dove balance.

In Figure 2, the dashed line presents the FOMC rotation instrument over time. On average, the rotating presidents are more hawkish than the overall FOMC Hawk-Dove balance, reflecting the fact that FRB presidents tend to be more hawkish than governors (Chappell et al., 2005; Istrefi, 2019; Bordo and Istrefi, 2023). Both series display sizable variation over time, but fluctuations in the instrument $Hawk_t^{IV}$ are more short-lived, with a year-over-year autocorrelation of 0.20 compared to 0.66 for $Hawk_t$, see Table 1.

Table 1: Summary statistics

	Mean	Median	SD	Autocorr	Corr	Min	Max	T
$Hawk_t$	0.04	0.09	0.35	0.66	-	-0.80	0.67	253
$Hawk_t^{IV}$	0.28	0.33	0.45	0.20	0.64	-0.75	1.00	253

Notes: Summary statistics for the quarterly time series from 1960 until 2023. $Hawk_t$ is the average Hawk-Dove balance of the FOMC. $Hawk_t^{IV}$ is the FOMC rotation instrument. Autocorr refers to the year-over-year first-order autocorrelation. Corr refers to the correlation with $Hawk_t$.

Relevance of instrument. Our instrument $Hawk_t^{IV}$ aggregates the policy preferences of one-third of the FOMC members, capturing a significant part of the variation in the overall Hawk-Dove balance $Hawk_t$. In fact, the correlation between $Hawk_t$ and $Hawk_t^{IV}$ is 0.64. Formal weak instrument tests require a fully specified regression model and are therefore delegated to Section 4. However, we can estimate a stylized first-stage regression to study the explanatory power of the FOMC rotation instrument. We regress $Hawk_t$ on $Hawk_t^{IV}$ and a constant. This regression has an R^2 of 0.41 and an effective F-statistic (Montiel Olea and Pflueger, 2013) for joint significance of 46.13, well above the common threshold of 10 for weak instruments (Andrews et al., 2019).

We further provide a decomposition of $Hawk_t$ into intensive margin changes of incumbent FOMC members' policy preferences and extensive margin changes in the composition of the FOMC due to entry and exit, see Appendix C for details. We find that extensive margin changes in the FOMC composition due to the rotation account for 53% of the variance in yearly changes of $Hawk_t$. The turnover of non-rotating FOMC members accounts for another quarter of the variance, and the remainder is due to preference changes of incumbent FOMC members and various covariance terms. Both the first-stage regression and the variance decomposition strongly suggest that our instrument is relevant for $Hawk_t$.

Finally, the rotation is considered important by Fed watchers in the media. Each year before the rotation, they discuss its implications for monetary policy. A typical media discussion, here an article in The New York Times from January 1, 2011, reads as follows:

[20] In our sample, $|\mathcal{R}_\tau| = 4$ for 625 out of 634 FOMC meetings and $|\mathcal{R}_\tau| = 3$ for the remaining nine meetings because of an absent member.

> *As the Federal Reserve debates whether to scale back, continue or expand its $600 billion effort to nurse the economic recovery, four men will have a newly prominent role in influencing the central bank's path. The four men are presidents of regional Fed banks, and under an arcane system that dates to the Depression, they will become voting members in 2011 on the Federal Open Market Committee, [...] the change in voting composition is likely to give the committee a somewhat more hawkish cast. This could amplify anxieties about unforeseen effects of Bernanke's policies [...]. Two of the four new voters are viewed as hawkish on inflation, meaning that they tend to be more worried about unleashing future inflation than they are about reducing unemployment in the short run.*

Exogeneity of instrument. We next argue that variation in $Hawk_t^{IV}$ is quasi-exogenous. First, the rotation scheme is mechanical and time-invariant and therefore unrelated to the state of the economy. Second, new appointments of FRB presidents are relatively infrequent and unlikely to be influenced by the federal government. FRB presidents are appointed by the Board of Directors of the respective Federal Reserve district. The directors are to represent the broader public and financial institutions located in the district. In contrast, members of the Board of Governors (including the Fed Chair) are nominated by the U.S. president and confirmed by the Senate. Furthermore, the average tenure of an FRB president is eleven years but only seven years for a governor in our sample. Relatedly, Bordo and Istrefi (2023) show that different from governors, there is no correlation between the preferences of the FRB presidents and the U.S. president's party at the time of their appointment. In addition, some regional FRBs have persistent leanings toward either the dovish or the hawkish camp. For example, the Cleveland FRB president is typically a hawk whereas the president of the San Francisco FRB is typically a dove.

Third, swings of preferences are likely a negligible threat to the exogeneity of our instrument. For rotating FOMC members, swings occur only in 1.3% of member-meetings pairs, and not all swings are endogenous to the state of the economy.[21] In addition, we find that swings account for a negligible fraction of the variance of the rotation instrument. In particular, we decompose $Hawk_t^{IV}$ into intensive margin changes of preferences (swings) and extensive margin changes of the composition of rotating FOMC members due to either the rotation or appointments, see Appendix C for details. The rotation accounts for 93% of the variance in yearly changes of $Hawk_t^{IV}$, appointments for 8% and swings for 1%.[22] Fourth, $Hawk_t^{IV}$ displays relatively short-lived time series fluctuations that are unlikely to be correlated with slow-moving macroeconomic trends, such as increasing market power, female labor force participation, and various technological innovations. Similarly, $Hawk_t^{IV}$ is uncorrelated with business cycle fluctuations. For example, the correlation between $Hawk_t^{IV}$ and yearly real GDP growth is -0.02 and statistically insignificant. In contrast, the correlation between $Hawk_t$ and GDP growth is 0.15 and

[21] Bordo and Istrefi (2023) discuss three major swing waves in the FOMC during 1960-2014. The first wave is a hawkish wave influenced by inflation dynamics in the late 1960s to early 1970s. The second wave is a hawkish swing in the early 1990s, related to the discussion on inflation targeting inspired by the announcements of the Reserve Bank of New Zealand and Bank of Canada. Finally, the third swing wave is a dovish one in the late 1990s, following a new understanding of the economy.

[22] Our empirical results are robust to excluding swingers from our instrumental variable, see Section 4.5.

significant at the 5% level.

Overall, the above arguments support the validity of our FOMC rotation instrument for identifying the causal effects of systematic monetary policy. To the best of our knowledge, this paper is the first to propose an instrument for systematic monetary policy. We believe this is a substantial contribution to the literature which opens up myriad research questions.

A validation exercise for $Hawk_t$ and $Hawk_t^{IV}$. Given our definition of hawkish policy makers and conventional wisdom about hawkish monetary policy, we should expect a hawkish FOMC to respond more aggressively to inflation. As validation exercise, we empirically test this correlation via a dynamic Taylor rule regression. We use $Hawk_t^{IV}$ as instrument in a local projection of the federal funds rate on the Greenbook inflation forecast interacted with $Hawk_t$. We find that a hawkish FOMC indeed raises the federal funds rate significantly more aggressively in the presence of higher inflation forecasts. For more details on the exercise, the results, and a weak instrument test, see Appendix E. Overall, this exercise suggests that $Hawk_t$ and $Hawk_t^{IV}$ capture important variation in systematic monetary policy.

3.3 Local projection framework

Finally, we propose to combine $Hawk_t$ and $Hawk_t^{IV}$ in a state-dependent local projection framework that permits causal identification of how systematic monetary policy shapes the propagation of various macroeconomic shocks. The setup of the local projection is consistent with the New Keynesian model discussed in Section 2.

We regress an outcome variable of interest, x_{t+h}, on a macroeconomic shock of interest, ε_t^s, the interaction of the shock with the Hawk-Dove balance $Hawk_t$, as well as $Hawk_t$ in levels and a vector of additional control variables Z_t. Formally,

$$x_{t+h} = \alpha^h + \beta^h \varepsilon_t^s + \gamma^h \varepsilon_t^s (Hawk_t - \overline{Hawk}) + \delta^h (Hawk_t - \overline{Hawk}) + \zeta^h Z_t + v_{t+h}^h, \tag{3.4}$$

for $h = 0, \ldots, H$ forecast horizons. $\overline{Hawk}$ denotes the arithmetic sample mean of $Hawk_t$. To address the potential endogeneity of $Hawk_t$, we use the instrument vector

$$q_t = \left[\, 1,\ \varepsilon_t^s,\ \varepsilon_t^s \left(Hawk_t^{IV} - \overline{Hawk}^{IV}\right),\ \left(Hawk_t^{IV} - \overline{Hawk}^{IV}\right),\ Z_t \,\right] \tag{3.5}$$

for the regressors in (3.4). The two key coefficients in (3.4) are β^h and γ^h, which capture the average response, when the Hawk-Dove balance of the FOMC is at its sample average, and the differential response, when the FOMC is more or less hawkish than the sample average. Based on Section 2, the IV estimator is consistent if the instrument $Hawk_t^{IV}$ is orthogonal to all macroeconomic shocks (both observed shocks ε_t^s and other unobserved shocks) at all lags and leads. In the next section, we discuss whether the identifying assumptions are satisfied in the context of a government spending shock.

In general, this framework can be used to study the propagation of any shock through systematic U.S. monetary policy. Our framework permits revisiting a range of important empirical questions, such as the role of systematic monetary policy for the effects of oil-related shocks (e.g., Bernanke et al., 1997; Kilian and Lewis, 2011), technology shocks (e.g., Galí et al., 2003), news shocks (e.g., Barsky and Sims, 2011), fiscal spending shocks (e.g., Ramey and Zubairy, 2018), and tax shocks (e.g., Romer and Romer, 2010). Moreover, our framework allows the estimation of a new set of moments that can be used to discipline structural models with time variation in systematic monetary policy, such as regime-switching models (e.g., Davig and Leeper, 2007; Bianchi, 2013; Bianchi and Ilut, 2017).

4 Government spending and monetary policy

In this section, we use our identification design to estimate how the effects of U.S. government spending shocks depend on systematic monetary policy. We find that a hawkish FOMC significantly dampens the expansionary effects of increased government spending on GDP, while a dovish FOMC supports it. Relatedly, we find sizeable differences in the fiscal multiplier depending on the hawkishness or dovishness of the FOMC. We further provide evidence on the strength of our instrument, and perform an extensive sensitivity analysis considering alternative Hawk-Dove balances, an alternative spending shock, varying sample periods, and the inclusion of additional control variables.

4.1 Data and identifying assumptions

We next discuss the data (in addition to $Hawk_t$ and $Hawk_t^{IV}$) and the identifying assumptions for our analysis of government spending shocks.

Variables. We first specify the local projection framework (3.4)-(3.5). Our baseline shock of interest, ε_t^s in (3.4), is the military spending shock constructed by Ramey (2011) and Ramey and Zubairy (2018), based on a narrative approach to identify surprise build-ups (or build-downs) in U.S. military spending. The shock is constructed as the present value of expected changes in real defense spending over the next years, typically up to a horizon of five years, and expressed relative to real potential GDP. The two outcome variables of interest, x_{t+h} in (3.4), are real GDP and real government spending, both expressed relative to real potential GDP.[23] Finally, the vector of control variables, Z_t in (3.4), includes four lags of real GDP and real government spending, both relative to potential output and four lags of the fiscal spending shock. If we restrict $\gamma^h = \delta^h = 0$, our specification of (3.4) corresponds to equation (1) of Ramey and Zubairy (2018). This facilitates the comparability of our results with the literature.

Sample. Our baseline sample covers the period from 1960Q1 to 2014Q4, which is the longest possible sample for which the Hawk-Dove balance and the fiscal spending shocks are available. Our sample includes important military spending shocks, e.g., the Vietnam War, the Carter-Reagan military buildup, and 9/11. On the other hand, our sample excludes WWII and the Korean War which are important events in Ramey (2011) and Ramey and Zubairy (2018).[24] In

[23] Detrending by potential GDP is the so-called Gordon and Krenn (2010) transformation. Compared to using log variables, this avoids using an ex-post multiplication with the GDP/G ratio, which substantially varies over time, to obtain the fiscal spending multiplier.

[24] Ramey (2011) shows that excluding the Korean War renders military spending shocks a weak instrument for contemporaneous government spending. In general, it is not surprising that military spending shocks are a

the context of studying the response of monetary policy to fiscal spending shocks, however, it may be desirable to exclude these events because monetary policy was less autonomous from fiscal policy prior to the Treasury-Fed Accord in 1951. Between 1942 and 1951, the Fed was constrained to support government bond prices by pegging short-term interest rates.

Identifying assumptions. Two key identifying assumptions are necessary for the causal interpretation of the estimates of β^h and γ^h in (3.4).

The first assumption is that military spending shocks are random shocks. In particular, the distribution of military spending shocks does not depend on systematic monetary policy. According to Ramey and Shapiro (1998) and Ramey and Zubairy (2018), military spending shocks are unanticipated changes in spending plans triggered by geopolitical events and are therefore exogenous to the economy. This argument similarly applies when conditioning on systematic monetary policy. We provide three additional arguments as to why the military spending shocks are independent of systematic monetary policy: (i) the response of military spending to the shock does not depend on systematic monetary policy, see Section 5.2; (ii) the news quotes used to construct military spending shocks as described in the supplementary appendix to Ramey and Zubairy (2018) do not mention monetary policy, the Federal Reserve, or the FOMC for our sample; and (iii) the Hawk-Dove balance does not predict future spending shocks. The specific concern the last point addresses is that military spending shocks might be timed to episodes with a more dovish FOMC. To test this concern we regress future military spending shocks on $Hawk_t$ and use $Hawk_t^{IV}$ as an instrument. We find no significant effects of the Hawk-Dove balance on contemporaneous or future military spending shocks, see Figure G.1 in Appendix H. If anything, we find expansionary shocks when the FOMC is hawkish, inconsistent with the timing hypothesis above.

The second assumption is that the FOMC rotation instrument is orthogonal to other macroeconomic shocks at all leads and lags. This is plausible for various reasons as discussed in Section 3.2. More specifically, given that fluctuations in $Hawk_t^{IV}$ are relatively short-lived and uncorrelated with real GDP growth, it is unlikely that our estimates capture differences in the response across booms and busts (e.g., Auerbach and Gorodnichenko, 2012; Ramey and Zubairy, 2018). It is similarly unlikely that $Hawk_t^{IV}$ correlates with changes in systematic fiscal policy, which tends to be persistent.

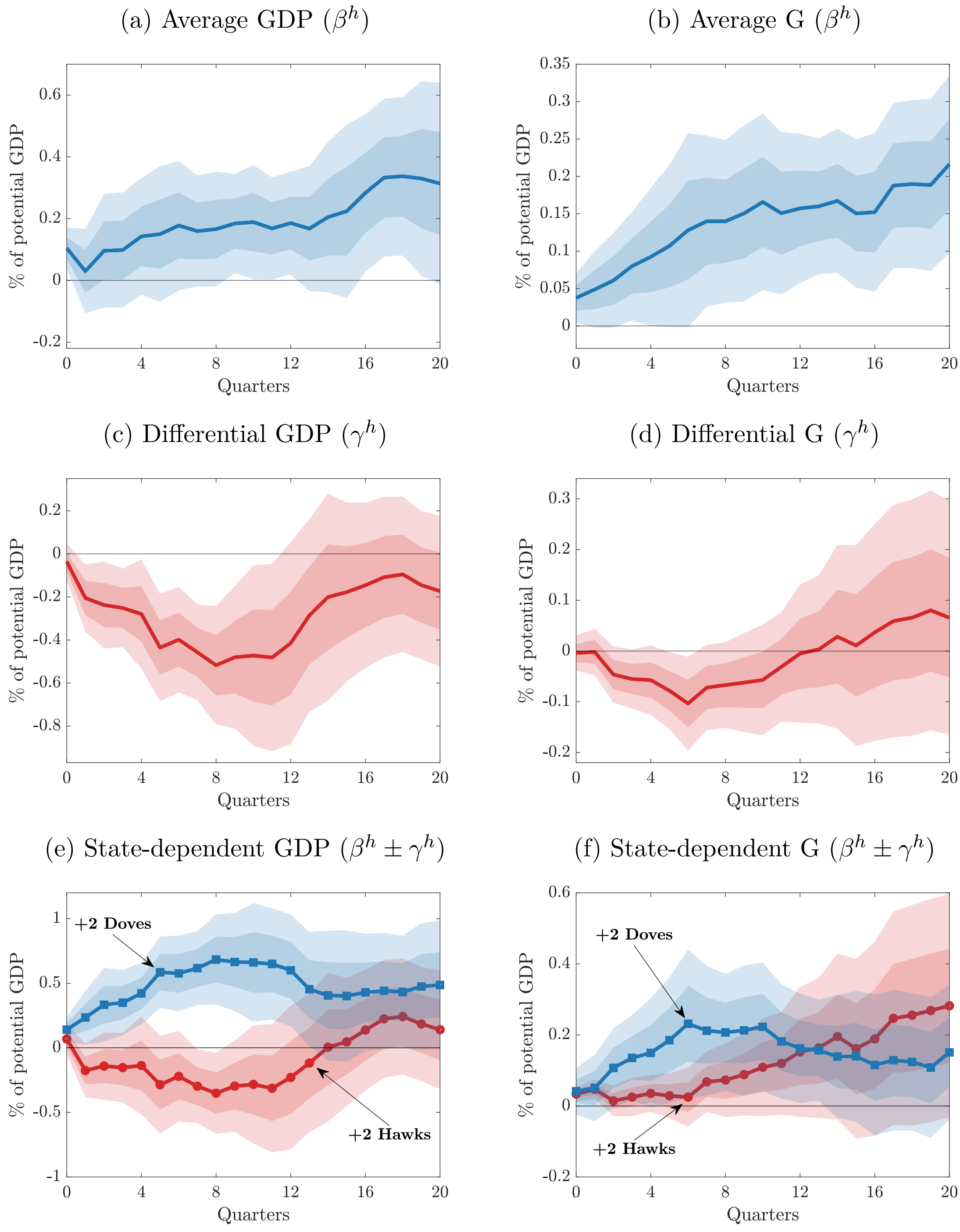
4.2 GDP and government spending

We next present our empirical estimates of the causal effects of systematic monetary policy on the responses of real GDP and real government spending to fiscal spending shocks. We find that expansionary spending shocks raise GDP significantly more strongly when the FOMC is more dovish.

Baseline IV estimates. Figure 3 shows the responses of real GDP and real government spending (G) to a military spending shock conditional on systematic monetary policy ($Hawk_t$).

weak instrument for contemporaneous government spending because the shocks largely pertain to future spending. Therefore, we do not use military spending shocks as an instrument but as shocks in our local projection framework (3.4) and find a significant dynamic government spending response, see Section 4.2.

Figure 3: Responses to spending shocks conditional on monetary policy



Notes: The figure shows responses of real GDP and real government spending (G) to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The β^h captures the responses when $Hawk_t$ equals its sample average. The γ^h captures the differential responses when $Hawk_t$ exceeds the sample average by two hawks. The $\beta^h \pm \gamma^h$ shows the state-dependent responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.

The estimates are based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The solid lines show the point estimates and the shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.[25] All estimates of β^h and γ^h are normalized to correspond to an expansionary shock that raises the expected present discounted value of future military spending by one percent of GDP.[26]

Panels (a) and (b) show the IV estimates of β^h for GDP and G, which capture the responses when $Hawk_t$ equals its sample average. The average responses of both GDP and G are positive and significantly different from zero at most horizons beyond the first year. Both responses build up gradually and exceed 0.15% for GDP and 0.11% for G after one year.

Panels (c) and (d) show the estimates of γ^h, which capture the differential responses of GDP and G when the FOMC exceeds the average Hawk-Dove balance by two hawks. Specifically, γ^h is scaled to capture an increase in $(Hawk_t - \overline{Hawk})$ of 2/12. This means, for example, that two FOMC members with unknown preferences are replaced by two consistent hawks, or that two FOMC members swing from dovish to hawkish. An increase in $Hawk_t$ by 2/12 exceeds one standard deviation of the change in $Hawk_t$ which is 0.15. Importantly, the GDP response is lower after a fiscal expansion when the FOMC is more hawkish. This effect is statistically significant at the 5% level until three years after the shock. The estimated magnitudes are sizeable. Between two and three years after the shock the GDP response is more than 0.4% lower under a more hawkish FOMC. Conversely, the GDP response is 0.4% higher when there are two more doves in the FOMC. The differential response of government spending (G) is also negative at horizons until three years after the shock, albeit smaller in absolute terms and less significant. In Section 5.2, we show that the differential G response is driven by non-military spending, whereas we find no meaningful differential effect for military spending.

Panels (e) and (f) of Figure 3 show $\beta^h \pm \gamma^h$, the state-dependent responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). The GDP response strongly varies between the dovish and the hawkish FOMC. The dovish FOMC supports the GDP expansion while the hawkish FOMC undoes the GDP expansion. Quantitatively, GDP increases by up to 0.68% under the dovish FOMC, but falls by up to 0.35% under the hawkish FOMC. The former response is highly statistically significant, whereas the latter response is less precisely estimated.

Overall, our evidence suggests that monetary offset of fiscal spending shocks is not a constant feature of monetary policy but varies strongly with the Hawk-Dove balance in the FOMC. In contrast to the GDP response, government spending displays smaller and less significant differences in the state-dependent responses.

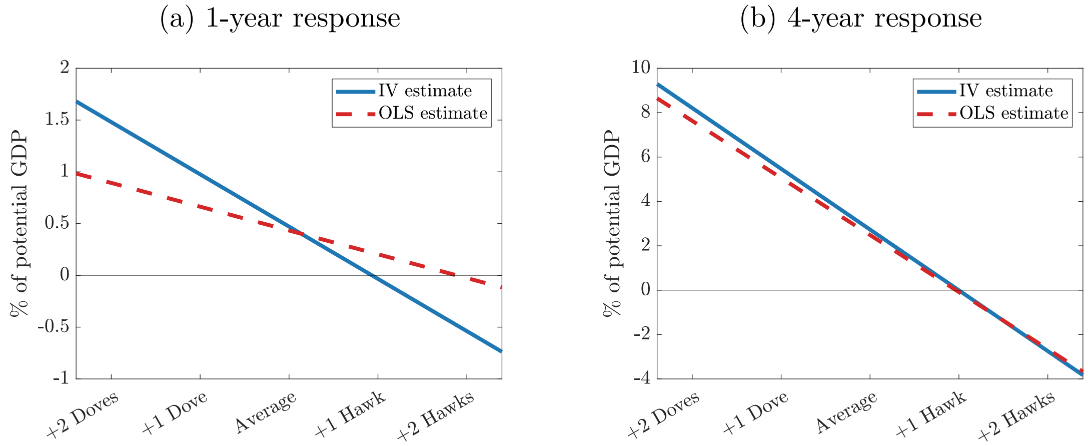
Comparison with OLS. We compare our IV estimates presented above with the OLS counterparts. Figure 4 shows the OLS and IV estimates of cumulative GDP responses to a military shock as a function of the FOMC's Hawk-Dove balance. At horizons of around one year, the OLS estimates substantially understate the dependence of the GDP response on the Hawk-Dove balance. In contrast, at long horizons of around four years, the OLS bias seems negligible.[27]

[25]For the Newey-West standard errors, we set the bandwidth to $h + 1$, where h is the horizon in (3.4). A truncation parameter rule (Lazarus et al., 2018) or automatic bandwidth selection leads to similar results.

[26]Normalizing the responses to a shock size of 1% of GDP approximately normalizes to one standard deviation of the shock series, which is 1.17% of GDP.

[27]Figure G.3 in the Appendix presents the cumulated responses at intermediate horizons of two and three years. Figure G.2 presents the OLS estimates of β^h and γ^h.

Figure 4: Cumulative GDP responses for OLS and IV



Notes: The figure shows the cumulative real GDP response to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show IV and OLS estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The displayed estimates are computed as $\sum_{h=0}^{H}[\beta^h + \gamma^h(Hawk_t - \overline{Hawk_t})]$ for $H = 4$ quarters (Panel a) and $H = 16$ quarters (Panel b).

This comparison suggests that ignoring the endogeneity of $Hawk_t$ leads to biased conclusions about the role of systematic monetary policy for fiscal spending shocks.

4.3 Weak instruments

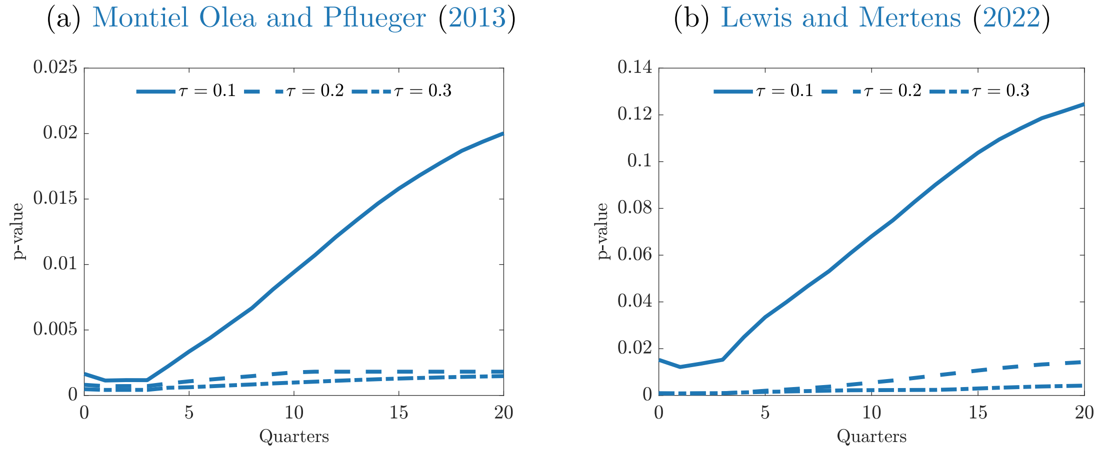
A common concern with IV estimates is the strength of the instrument. We provide evidence supporting the strength of our instruments, including weak instrument tests and weak instrument-robust inference, reinforcing the contribution of our identification design.

First-stage results. Our local projection framework (3.4) contains two endogenous regressors, $\varepsilon_t^s(Hawk_t - \overline{Hawk})$ and $(Hawk_t - \overline{Hawk})$. The estimates of the two associated first-stage regressions are shown in Table G.1 in the Appendix. We find that the instrumental variable $\varepsilon_t^s(Hawk_t^{IV} - \overline{Hawk}^{IV})$ has a positive effect on the endogenous variable $\varepsilon_t^s(Hawk_t - \overline{Hawk})$ and is significant at the one percent level. Similarly, $(Hawk_t^{IV} - \overline{Hawk}^{IV})$ has a positive and highly significant effect on $(Hawk_t - \overline{Hawk})$. In both regressions, the R^2 increases by about 0.4 when including the instruments as regressors and we also find large jumps up in the associated Kleibergen-Paap F-statistics. Taken together, this suggests that our instruments are strong (Bound et al., 1995).

Weak instrument tests. We further use three statistical tests to assess the strength of our instrument more formally. First, we use the Montiel Olea and Pflueger (2013) test of weak instruments, which is popular in time series settings because it is robust to autocorrelation and heteroskedasticity. Formally, we test whether the relative weak instrument bias for the IV estimates of γ^h exceeds 10%, 20%, or 30%.[28] Panel (a) of Figure 5 shows the p-values of the

[28] We apply the test to γ^h because it is our main coefficient of interest (together with β^h), and because the Montiel Olea and Pflueger (2013) test can only be applied to a single endogenous regressor. For the other endogenous regressor, $(Hawk_t - \overline{Hawk})$ in levels, we estimate the first stage separately and plug in the fitted values in the second stage used to test the interaction term. If we alternatively replace $Hawk_t$ level term by

Figure 5: Weak instrument tests



Notes: The figure shows p-values for rejecting the null of weak instruments for the responses of real GDP, based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The Montiel Olea and Pflueger (2013) test evaluates the null of the bias in γ^h exceeding a threshold τ. Similarly, the Lewis and Mertens (2022) test evaluates the null of the ℓ^2 norm of the bias in γ^h and δ^h exceeding a threshold τ. For the former, the endogenous regressor $Hawk_t$ is not tested but directly replaced by its first stage fitted value. The critical values and associated p-values are based on Newey-West standard errors.

weak instrument tests for the differential GDP response. At all horizons, even a relatively small 10% bias ($\tau = 0.1$) can be rejected at significance levels below 2%.

The second weak instrument test we apply was recently developed by Lewis and Mertens (2022) and generalizes Montiel Olea and Pflueger (2013) to allow for multiple endogenous regressors. We apply this test to jointly evaluate whether the average relative bias across γ^h and δ^h exceeds some threshold τ and report the results in Panel (b) of Figure 5. A small average bias of 10% can be rejected at significance levels below 10% for most horizons. Moreover, we can reject a bias of 20% at the two percent level for all horizons. For government spending, both tests lead to the same conclusion, see Figure G.4 in Appendix G.

Lastly, we test for weak instruments via the reduced form of our regression framework. Following Chernozhukov and Hansen (2008), the hypothesis test of the reduced form estimates of γ^h against zero is equivalent to testing whether the instrument has zero relevance. Figure G.5 in the Appendix shows that the reduced-form estimates for γ^h are significant, as in Figure 3. To summarize, all three tests indicate that our instruments are not weak.

Weak instrument-robust inference. To address residual concerns about instrument strength, we further provide inference that is robust to weak instruments and allows for multiple endogenous regressors based on Andrews (2018). We find robust confidence sets for the differential GDP and G responses similar to our baseline intervals, see Figure G.6 in the Appendix. This provides additional support for the strength of our instruments.

4.4 Fiscal spending multiplier

A key object for the design and evaluation of fiscal policies is the fiscal spending multiplier. We use our framework to estimate how the fiscal spending multiplier depends on the hawkishness

$Hawk_t^{IV}$ we obtain very similar results.

of the FOMC. We find that a dovish FOMC leads to substantially larger multipliers, relative to an average or a more hawkish FOMC composition.

Definition and estimation. The multiplier is defined as the dollar amount by which GDP increases per dollar increase in fiscal spending (both in real terms). A common procedure is to compute the multiplier as the cumulative response of GDP to a spending shock divided by the cumulative response of government spending to the same shock over some horizons of interest (e.g., Mountford and Uhlig, 2009; Ramey and Zubairy, 2018). To study how systematic monetary policy shapes the fiscal multiplier, we define the monetary policy-dependent fiscal multiplier as

$$FM^H(\chi) = \frac{\sum_{h=0}^{H} \beta_{\text{GDP}}^h + \gamma_{\text{GDP}}^h \chi}{\sum_{h=0}^{H} \beta_{\text{G}}^h + \gamma_{\text{G}}^h \chi} \tag{4.1}$$

where H is the maximal considered forecast horizon, β_i^h and γ_i^h are the average and differential responses of outcome $i \in \{\text{GDP}, \text{G}\}$ to a spending shock, and χ indicates some level of the Hawk-Dove balance in deviation from the sample mean ($Hawk_t - \overline{Hawk}$).
We estimate the cumulative average and differential responses, $\sum_{h=0}^{H} \beta_i^h$ and $\sum_{h=0}^{H} \gamma_i^h$, in one step by replacing the left-hand side of the local projection in (3.4) by the cumulative outcome between $h = 0$ and H. Otherwise, we exactly follow Section 4.2 and use the specification of the local projection framework in Section 4.1. We construct valid standard errors for $FM^H(\chi)$ by accounting for the covariance between the estimates in the numerator and denominator of (4.1). Appendix F provides further details and a comparison of our multiplier estimation with the approach in Ramey and Zubairy (2018).

Results. Table 2 presents the IV estimates of the fiscal spending multipliers $FM^H(\chi)$ for both a two-year and a four-year horizon. For an average Hawk-Dove balance, $\chi = 0$, the cumulative spending multiplier is 1.3 at both horizons, and significantly different from zero at the 10% level. Analogous to Figure 3, we consider a range of χ from $-2/12$ to $+2/12$. As the FOMC becomes more dovish than average, the multiplier increases from 1.3 to 2.3 for one additional dove ($\chi = -1/12$), and to 3 for two additional doves ($\chi = -2/12$). The difference between the average and the dovish multipliers are similar across the two horizons. Moreover, the difference is statistically significant at the 5% level for the four-year horizon, see Table G.3 in Appendix G. Conversely, as the FOMC becomes more hawkish, the multiplier $FM^H(\chi)$ drops to zero or below and is insignificantly different from zero. The differences in $FM^H(\chi)$ across χ are mainly driven by differences in the cumulative GDP response rather than the G response. The differences in the GDP response across χ are larger in magnitude and more significant, see Table G.2. This result is analogous to the findings in Figure 3.

Comparison with linear model. We explicitly estimate how the fiscal spending multiplier depends on systematic monetary policy, whereas much of the related literature has estimated a single 'average' fiscal spending multiplier (e.g., Blanchard and Perotti, 2002; Ramey, 2016). To compare our results with this tradition in the literature, we estimate an average fiscal spending

Table 2: Government spending multipliers and monetary policy

Outcome	Baseline model: +2 Hawks	+1 Hawk	Average	+1 Dove	+2 Doves	Linear model
			Two-year horizon			
Multiplier	-4.825	-0.476	1.348	2.351	2.986	0.860
	(5.229)	(1.418)	(0.708)	(0.934)	(1.239)	(1.427)
GDP (*cum*)	-1.689	-0.282	1.124	2.531	3.937	0.616
	(0.989)	(0.768)	(0.649)	(0.689)	(0.865)	(1.057)
G (*cum*)	0.350	0.592	0.834	1.076	1.319	0.716
	(0.250)	(0.300)	(0.395)	(0.510)	(0.634)	(0.338)
			Four-year horizon			
Multiplier	-1.790	-0.001	1.308	2.307	3.095	0.838
	(2.637)	(0.862)	(0.475)	(0.808)	(1.162)	(1.449)
GDP (*cum*)	-2.735	-0.002	2.731	5.465	8.198	1.494
	(2.498)	(1.557)	(0.842)	(1.045)	(1.892)	(2.747)
G (*cum*)	1.528	1.808	2.088	2.368	2.649	1.782
	(1.010)	(0.804)	(0.734)	(0.848)	(1.079)	(0.689)

Notes: The table shows IV estimates of the cumulative fiscal spending multipliers $FM^H(\chi)$ in equation (4.1) for $H = 8$ (top panel) and $H = 16$ quarters (bottom panel), as well as the cumulative GDP response (numerator of $FM^H(\chi)$) and the cumulative G response (denominator of $FM^H(\chi)$). The coefficients are estimated using a cumulative version of the local projection framework (3.4)-(3.5) as specified in Section 4.1. For our baseline model, the columns present different states of the Hawk-Dove balance between "+2 Hawks" ($\chi = +2/12$), "Average" ($\chi = 0$), and "+2 Doves" ($\chi = -2/12$). The linear model in the last column presents the estimates when we restrict $\gamma^h = \delta^h = 0$ in the local projection (3.4). Driscoll-Kraay standard errors are in parenthesis, see Appendix F for details.

multiplier in a linear version of our framework. To be precise, we estimate (3.4) using the same data but restricting $\gamma^h = \delta^h = 0$. We then use the estimates of β^h from the linear model to compute the fiscal multiplier $\widetilde{FM}^H = (\sum_{h=0}^{H} \beta^h_{\text{GDP}})/(\sum_{h=0}^{H} \beta^h_{\text{G}})$. The resulting estimates are presented in the last column of Table 2. We find average multipliers of about 0.85 at both horizons. While this estimate is relatively close to the multiplier estimates in Ramey and Zubairy (2018) which range from 0.66 to 0.71 (see their Table 1), it is substantially below the multiplier of 1.3 for an average FOMC composition ($FM^H(0)$) in our baseline model. In addition, the standard errors for the multiplier in the linear model are substantially larger than the standard errors of $FM^H(0)$. This comparison suggests that accounting for systematic monetary policy is important for the magnitude and precision of multiplier estimates. Moreover, one potential reason for the broad range of multiplier estimates in the literature is not accounting for time variation in systematic monetary policy.

4.5 Sensitivity analysis

In this section, we provide an extensive sensitivity analysis to assess the robustness of our baseline results. We investigate alternative Hawk-Dove balances, an alternative spending shock, varying sample periods, and the inclusion of additional control variables. The multiplier estimates for all specifications are provided in Appendix G.[29]

Alternative Hawk-Dove balances. We address potential concerns regarding the aggregation of individual policy preferences and the comparability of preferences over time.
While our baseline $Hawk_t$ aggregates individual preferences by an unweighted arithmetic average, we consider four alternative aggregation schemes. First, we use the median policy preference across FOMC members. Second, we use an arithmetic average but double the weight of the Fed Chair. Third, we use the arithmetic average but do not distinguish between consistent and swinging FOMC members when defining $Hawk_{i\tau}$ in (3.1). We estimate impulse responses and multipliers similar to the baseline, albeit smaller ones for the median aggregation, see Table G.3. In a fourth alternative aggregation, we consider the role of strong majorities in the FOMC. We construct an alternative Hawk-Dove balance which equals -1 if $Hawk_t$ falls below the first quartile or tertile of the distribution of $Hawk_t$ over time, +1 above the highest quartile or tertile, and zero otherwise. The estimated average and differential effects remain quite similar in terms of the shapes and significance and also roughly align with the baseline multipliers, see Table G.4. Finally, we construct an alternative instrument by setting the preferences of swinging FRB presidents to zero before aggregating them to the FOMC rotation instrument. This yields somewhat larger multiplier estimates, albeit less precisely estimated, see Table G.3. This suggests that swings in the instrument are not driving or amplifying our results.
Another potential concern is that the meaning of being a hawk or dove might have changed over time, see the discussion in Section 3.1. To account for trends in the Hawk-Dove balance, we consider an alternative Hawk-Dove balance which subtracts from the baseline $Hawk_t$ its backward-looking 5, 10, or 15-year moving average. The estimated average and differential responses are very similar to our baseline estimates. In addition, the average and dovish multipliers have similar magnitudes as the baseline while the hawkish multiplier is similarly imprecise, see Table G.3 in the Appendix. Overall, our results reinforce the arguments in Section 3.1 that the classification of hawks and doves is indeed comparable over time.

Alternative spending shock. Our baseline shock is specific to military spending. We investigate the external validity of our results by using an alternative fiscal spending shock, which is identified from a timing restriction on total government spending as suggested by Blanchard and Perotti (2002), henceforth BP. They assume that only government spending shocks can affect government spending contemporaneously.
We find that GDP and G respond more swiftly compared to our baseline. This is in line with the nature of the BP shock. More importantly, we find that a hawkish FOMC significantly dampens the expansionary effect on GDP. The average fiscal multiplier is around 1.4 for the

[29] For the impulse responses of GDP and G associated to the sensitivity analysis, see Appendix G of the CEPR Discussion Paper version (Hack et al., 2023, see https://cepr.org/publications/dp17999).

four-year horizon, see Table G.3, which is remarkably similar to our baseline multiplier. The state-dependent multiplier ranges from 0.88 to 1.74 between the hawkish and dovish FOMC ($\chi = \pm 2/12$). While the variation in the multiplier is more compressed compared to the baseline, it is similarly significant.

Great Recession and ZLB. Our baseline results are estimated using the sample from 1960Q1 to 2014Q4 which includes the Great Recession (GR) and the subsequent ZLB period. We investigate the sensitivity of our results on a sample that ends either in 2007Q4 to exclude the GR and ZLB period or in 2008Q4 to exclude the ZLB period. For both of these subsamples, our estimates are highly similar to the baseline for average and differential responses and the corresponding multipliers in Table G.3.

Additional control variables. Finally, we investigate the sensitivity of our results to adding potentially important co-variates to the baseline specification of our local projection framework. The additional control variables are short-term and long-term interest rates, inflation, and the primary surplus. While the estimates are similar to the baseline, we naturally give up some statistical power, see Table G.3. Nevertheless, we estimate dovish multipliers around 2 which substantially exceeds the average multiplier, consistent with our baseline results. We further add non-linear controls by including interactions of $Hawk_t$ with the control variables. The results are remarkably close to the baseline, see Table G.3.

5 Inspecting the mechanism

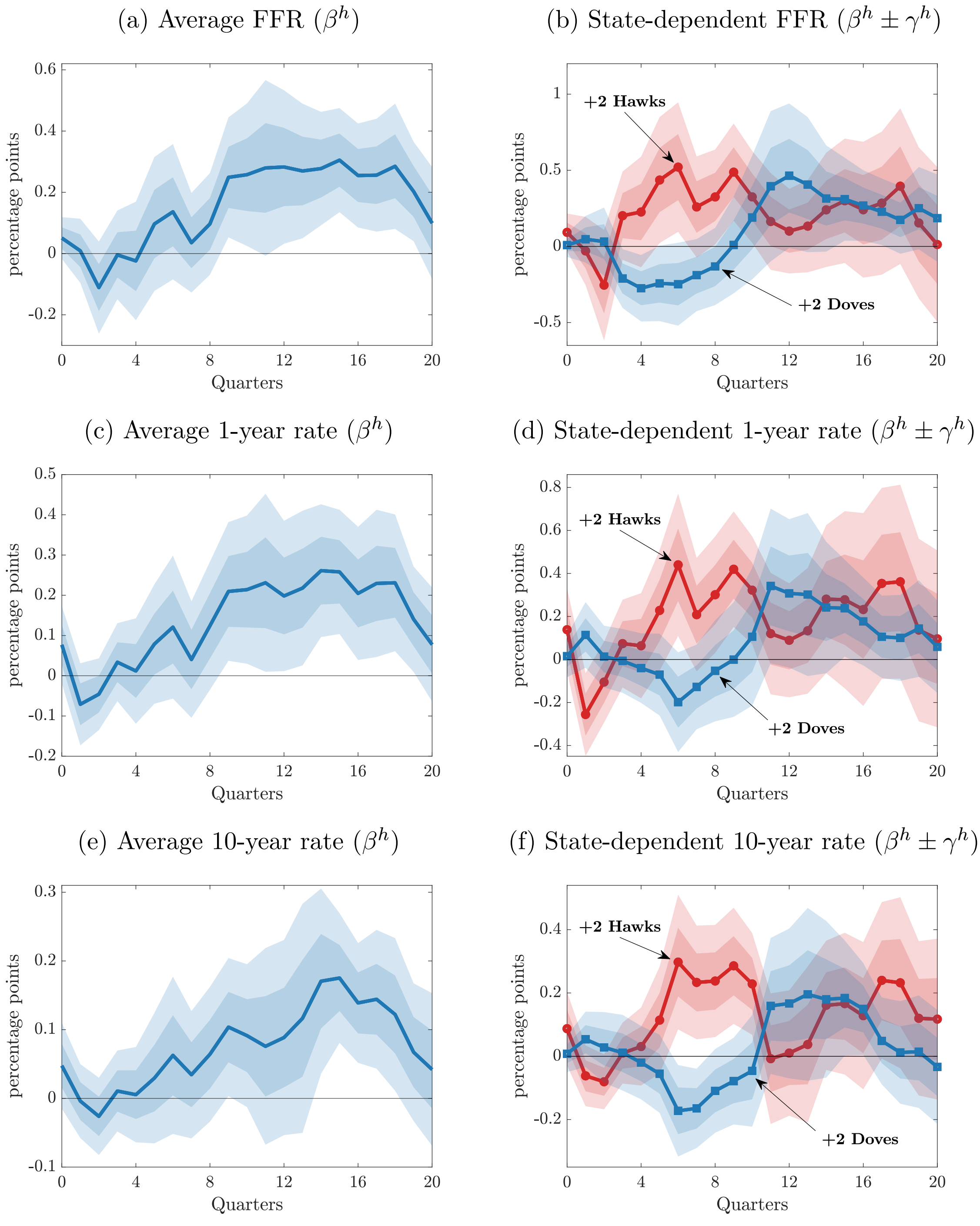
In this section, we inspect the mechanism behind our findings in the previous section. We show that in response to an expansionary spending shock, nominal and real interest rates rise and inflation is dampened under a hawkish FOMC. Conversely, interest rates initially fall and rise only with substantial delay under a dovish FOMC, supporting a crowd in of consumption and investment and an increase in non-military government spending. We argue that the fiscal multiplier estimates across hawkish and dovish monetary regimes are plausible given the different interest rate responses.

5.1 Interest rates and inflation

Conventional wisdom says that monetary policy tightens in response to higher government spending in order to mitigate the inflationary pressure. The Federal Reserve can use a range of tools, including the target federal funds rate, the discount rate, balance sheet policies and communication including forward guidance. These tools can affect short- and long-term interest rates, and hence inflation.

Nominal interest rates. We study the response of the federal funds rate (FFR) and the annualized yield on 1-year and 10-year Treasury securities to government spending shocks by using our local projection framework (3.4)-(3.5) with interest rates as outcome variable x_{t+h}. We follow the specification in Section 4.1 but include four lags of the FFR, 1-year and 10-year

Figure 6: Responses of nominal interest rates



Notes: The figure shows responses of the federal funds rate (FFR), as well as the 1-year and 10-year treasury yields to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). All outcomes are annualized interest rates. We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 5.1. The β^h captures the responses when $Hawk_t$ equals its sample average. The $\beta^h \pm \gamma^h$ shows the state-dependent responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.

Treasury yields, and CPI inflation as additional control variables to control for pre-trends in these outcomes.

Panels (a), (c) and (e) of Figure 6 show the IV estimates of β^h, the average response of the three nominal interest rates when $Hawk_t$ equals its sample average. The average FFR response appears muted in the first year, after which it gradually increases and reaches 30 basis points at horizons beyond two years. The average responses of the 1-year and 10-year yields feature similar shapes, albeit at lower magnitudes. Panels (b), (d) and (f) show the IV estimates of $\beta^h \pm \gamma^h$, the state-dependent interest rate responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). All interest rates increase faster and more strongly under a hawkish FOMC. Compared to the average response, the peak in the FFR is reached one year earlier and is almost double in size (about 56 basis points). In contrast, under a dovish FOMC, the FFR falls for almost two years and a reversion to a higher FFR is observed only three years after the shock. Similarly, both 1-year and 10-year Treasury yields increase after two years under a dovish FOMC, suggesting that the monetary regimes also differ in their effects on expected future policy at long horizons.

The delayed FFR response is consistent with the initial uncertainty surrounding the military spending shock and the gradually evolving macroeconomic effects of the shock, see Figure 3. Section 6 provides narrative evidence from the FOMC historical records suggesting that indeed the FOMC delays action until some uncertainty about the spending plans and their potential effect on the economy and inflation is resolved. Furthermore, a delayed differential policy response that extends for several quarters beyond the term of the FOMC and the associated rotation present at the time of the shock, is consistent with the decision dynamics in the FOMC. For example, Laurence Meyer, member of the Board of Governors from 1996 to 2002, describes these dynamics during his term at the Fed as follows:

> *So was the FOMC meeting merely a ritual dance? No. I came to see policy decisions as often evolving over at least a couple of meetings. The seeds were sown at one meeting and harvested at the next. [...] Similarly, while in my remarks to my colleagues it sounded as if I were addressing today's concerns and today's policy decisions, in reality I was often positioning myself, and my peers, for the next meeting.*
> Laurence Meyer (2004), A Term at the Fed: An Insider's View, Harper Business

Consistent with Meyer's view that it takes time to influence policy strategies in the FOMC, we find that the FOMC rotation ($Hawk_t^{IV}$) is more important for the policy response to the spending shock and its real effects when the shock occurs closer to the beginning of the FOMC rotation, which takes place in the first quarter of the year. When we drop spending shocks in the second half of the year, we obtain similar findings compared to the baseline, see Figures H.1-H.2 in Appendix H. Conversely, the dependence on monetary policy becomes weaker and less significant when dropping spending shocks in the first half of the year.

Inflation rates. We further asses the effects of military spending on inflation expectations, CPI core inflation (excluding food and energy prices), and CPI headline inflation.[30] We estimate the inflation responses using the specification of our local projection framework (3.4)-(3.5) for nominal interest rates and additionally control for four lags of the inflation measure under consideration. Overall, the inflation responses are not precisely estimated. The average response

[30]We use one-year inflation expectations based on the CPI forecasts from the Livingston Survey of the Federal Reserve Bank of Philadelphia. It is the oldest continuous survey on the expectations of economists from industry, government, banking, and academia. For details, see Appendix B.

of expected inflation tends to be positive, while the evidence is mixed for core and headline inflation. Turning to the dependence on the Hawk-Dove balance, we find that inflation expectations increase sluggishly under a dovish FOMC and peak at about three years. In contrast, inflation expectations tend to fall under a hawkish FOMC, suggesting that the FOMC is successful in containing inflation expectations. The response of core inflation follows a similar but even more sluggish pattern, suggesting that policy tightening is successful in containing inflationary pressures. Compared to the interest rate responses, the inflation response appear delayed by one to two years, broadly in line with the lags in the transmission of monetary policy. Finally, the results for headline inflation are more mixed, possibly due to larger transitory fluctuations in energy and food prices.

Real interest rates. In a large class of models, the real effects of monetary policy depend on its ability to affect real interest rates. Under a hawkish FOMC, the response of nominal rates is larger, while the response of inflation is smaller. Hence, the implied response of real interest rates is larger. In response to a government spending shock, real interest rates increase by more if the FOMC is hawkish and by less if the FOMC is dovish. We obtain similar results when directly estimating the real interest rate response. We consider real interest rates constructed by subtracting the expected CPI inflation from the three nominal interest rates considered in Figure 6. Figure H.3 in Appendix H presents the IV estimates of the average and state-dependent responses.

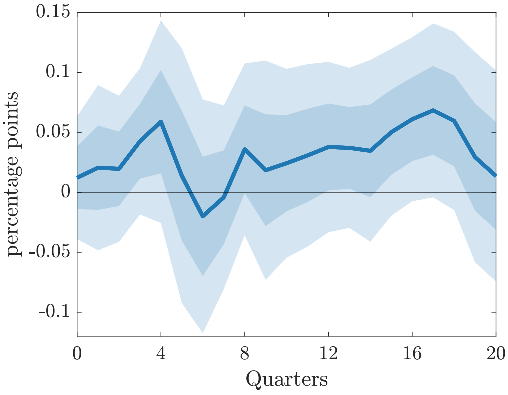
Relation to fiscal multipliers in the literature. The interest rate responses allow us to relate our fiscal spending multiplier estimates in Table 2 with the findings in the related literature. Our spending multiplier is between two and three under the dovish FOMC which is associated with a weak negative response of the nominal (and real) FFR for the first two years. In theory, the multiplier may be far above one (or negative) depending on the response of interest rates (Woodford, 2011; Farhi and Werning, 2016). In an estimated medium-scale DSGE model, Christiano et al. (2011) find multipliers between two and four at the ZLB when the short-run nominal interest rate does not respond.

Our findings also relate to an empirical literature that estimates fiscal spending multipliers. For example, Nakamura and Steinsson (2014) estimate two-year regional multipliers for the U.S. of approximately 1.5. To the extent that regional multipliers correspond to the aggregate multiplier when nominal interest rates do not respond, we can compare their estimates to our two-year multiplier estimates. In particular, we construct a spending multiplier for the case in which the nominal FFR is unresponsive by choosing the Hawk-Dove balance (χ) that minimizes the squared distance of the FFR response from zero in the first two years.[31] This requires a χ slightly below the "+1 Dove" case in Table 2. The associated two-year spending multiplier is 1.9, which is similar to the range of estimates in Nakamura and Steinsson (2014). While our identification design allows us to estimate the spending multiplier when monetary policy is non-responsive, it also allows us to study many other monetary policy scenarios.

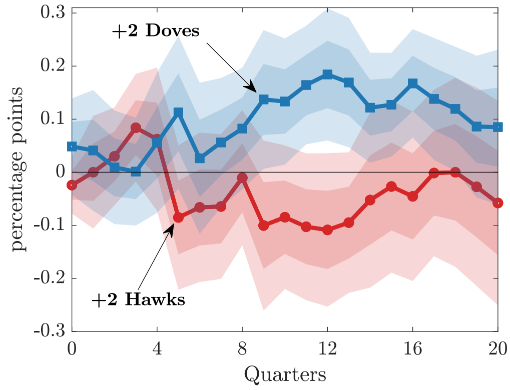
[31] Formally, we solve $\min_\chi \sum_{h=0}^{8}(\beta_{FFR}^h - \chi \cdot \gamma_{FFR}^h)^2$, where χ indicates a level of the Hawk-Dove balance in deviation from the sample mean ($Hawk_t - \overline{Hawk}$).

Figure 7: Responses of inflation rates

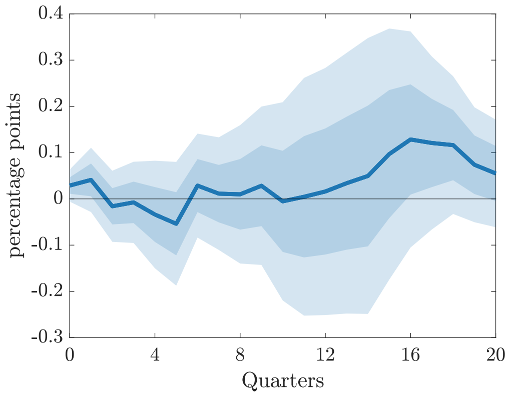
(a) Average expected inflation (β^h)



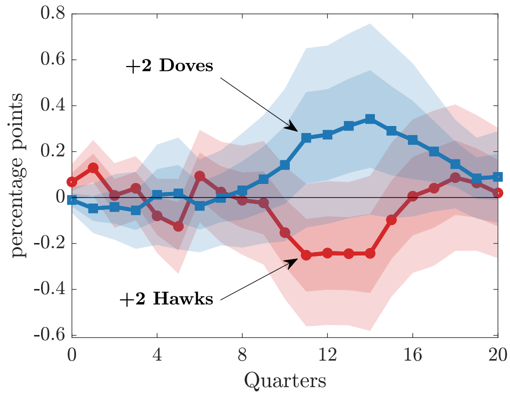
(b) State-dependent expected inflation ($\beta^H \pm \gamma^h$)



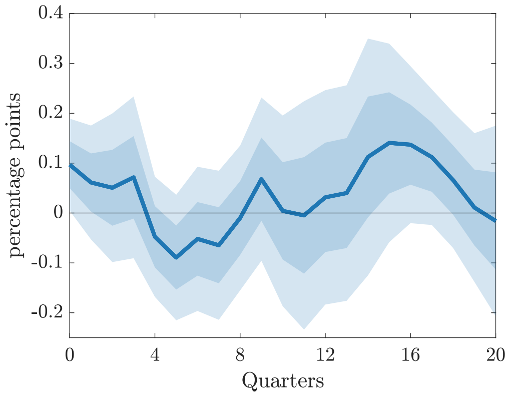
(c) Average core inflation (β^h)



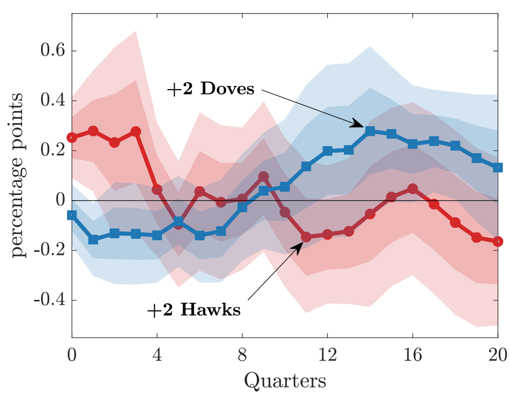
(d) State-dependent core inflation ($\beta^H \pm \gamma^h$)



(e) Average headline inflation (β^h)



(f) State-dependent headline inflation ($\beta^H \pm \gamma^h$)



Notes: The figure shows responses of expected inflation, CPI core, and CPI headline inflation to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). All outcomes are annualized inflation rates. We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 5.1. The β^h captures the responses when $Hawk_t$ equals its sample average. The $\beta^h \pm \gamma^h$ shows the state-dependent responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.

We further compare our estimates with the estimate of the aggregate spending multiplier when monetary policy is constrained at the ZLB. Ramey and Zubairy (2018) finds a ZLB multiplier of 1.6 after two years (when excluding WWII), while Miyamoto et al. (2018) find a ZLB multiplier well above 1.5 for Japan. Notwithstanding the endogeneity of a binding ZLB, our multiplier of 1.9 under a non-responsive FFR is similar to the ZLB multipliers in the literature. Overall, our multiplier estimates and the associated interest rate path are broadly similar to previous quantitative and empirical findings.

5.2 Decomposing the GDP and G responses

In the following, we examine the underlying components of the responses of real GDP and real government spending. We find that the differential GDP effects are primarily driven by private consumption and somewhat less by private investment. Moreover, the differential government spending response is almost entirely driven by non-military expenses, consistent with our identifying assumptions.

Investment and consumption. The fiscal spending multiplier can be above one when GDP components other than G are crowded in by the spending shock. Conversely, crowding out may lead to multipliers below one. Therefore, we estimate the responses of private investment and private consumption.[32] The results are provided in Figure H.4 in Appendix H. For the average Hawk-Dove balance, we find a mild but insignificant crowding out of private consumption and crowding-in of private investment in the short run. In contrast, the crowding out of consumption is strong and significant under a hawkish FOMC. For investment, we find a similar albeit smaller and less significant pattern. Overall, the strong state-dependence of our fiscal multipliers appears to be mainly driven by private consumption.

Military and non-military government spending. We further estimate the respective responses of military and non-military government spending to the military spending shock, see Figure H.5 in Appendix H. On average, we find a modest and insignificant decline in non-military spending. However, the government cuts non-military spending strongly and significantly under a hawkish FOMC. Fiscal policy responds to higher interest rates by lowering non-military spending, consistent with higher costs of servicing federal debt and lower tax revenues. This further contributes to the negative GDP response under a hawkish FOMC in addition to the contributions by consumption and investment. For military spending, we find the opposite. While the average response is large and significant, there is no meaningful dependence on the Hawk-Dove balance for military expenditures. This suggests that the shock is unrelated to systematic monetary policy, corroborating our key identifying assumptions, as discussed in Section 4.1.

6 Historical FOMC records

> *Interviewer*: What would have happened, do you think, if the Fed had not raised the discount rate?
> *Chairman Martin*: A golden opportunity to stop inflation in its tracks would have been lost.
> *Interviewer*: It was primarily the projection of Vietnam spending; is that correct?

[32] For details on the definition of consumption and investment, see Appendix B.

> *Chairman Martin*: Right. I kept telling him we could not have guns and butter.
> *Interviewer*: When you talked to Lyndon Johnson about this projection, what did he say? Did he disagree with it or did he agree with it?
> *Chairman Martin*: He disagreed. He thought we could have guns and butter.[33]

We complement our quantitative analysis with narrative evidence from the records of discussions and decisions at FOMC meetings. This evidence serves two purposes. First, it confirms that the FOMC members discuss changes in government defense spending, assessing the impact on economic activity and inflation as well as the FOMC's policy response. Second, it shows that the policy response depends on the composition of the FOMC.

To illustrate the FOMC discussion around military spending shocks, the FOMC composition, and the corresponding policy response, we focus on two important events during the 1960s: the acceleration of the U.S. Space Program in 1961 and the Vietnam ground war starting in 1965. The corresponding military shocks are both large while the FOMC composition appears on average hawkish in the first part of the 1960s and dovish in the second part, see Figure 2. In this period, the Fed was headed by William McChesney Martin, a consistent hawk whose tenure as chairman from 1951 to 1970 was the longest in history.

For both events, we identify three phases of the FOMC's reaction to military defense spending from the historical FOMC records. First, there is uncertainty about the extent to which the spending plans will be realized and about their impact on the economy. Second, the effects of higher spending on the economy become visible while inflation appears unresponsive, therefore they wait until "all the evidence was in". Third, the effects on inflation become visible but the FOMC delays action. The first two are common for hawkish and dovish committees while the third phase is more pronounced under a dovish one, broadly in line with our empirical findings. We summarize the key aspects of each case study below.[34] The sources for our narrative evidence are the FOMC Historical Minutes until 1967 and the Memoranda of Discussion thereafter.

6.1 The U.S. Space Program

In the first half of 1961, Ramey and Zubairy (2018) identify two expansionary shocks related to President Kennedy's defense spending plans, including the Space Program to "go to the Moon". In the FOMC meeting of August 1, 1961, the staff presents the following assessment:

> *On top of substantial increases in expenditures to finance space exploration and longer-run defense measures [...] the President has found it necessary to recommend an increase of $3-1/2 billion in current defense expenditures [...]. More important, the President accompanied his recommendations with a very firm statement regarding his intentions with respect to the 1963 budget. These factors have certainly tended to minimize the immediate inflationary expectations and the urgency of the need for counter-measures. As of this moment in time, actual developments do not seem to call for any change in monetary policy.* (p.8)

[33] Former Fed Chairman William McChesney Martin: Oral History, Interview I by Michael L. Gillette in 1987, LBJ Library Oral History Collection. The interviewer refers to the decision of the Federal Reserve to raise the discount rate on December 1965. Lyndon B. Johnson was the President of the United States from 1963 to 1969.

[34] The complete case studies can be found in Appendix I of the CEPR Discussion Paper version (Hack et al., 2023, see https://cepr.org/publications/dp17999).

The majority of the FOMC members argued similarly for no change in policy because the effects could not yet be evaluated. Hawkish FOMC members suggested the need for alertness to avoid getting into an inflationary situation while agreeing to no policy change in this meeting. In this regard, New York Fed first-vice president, William Treiber noted: *If expenditures and related private spending result in an upsurge of activity with inflationary aspects, we may have to modify our policy of basic monetary ease sooner than we would otherwise have done. In the coming period undue ease should be avoided.* (p.22-23)

FOMC members started to acknowledge the expansionary impact on employment and business sentiment in defense-related industries by the end of 1961 and later in 1963 on prices. On May 7, 1963, the FOMC voted to firm policy as a preemptive move against inflation.[35] In this meeting, Chairman Martin said:

> *If the Committee waited too long, however, it might have to deal with an active problem of inflationary pressures. In his opinion, there was already a good bit of pressure in some areas that could build up rapidly. If one waited until after the resulting price movements actually occurred, he might wonder why he had not done something about it before. It would be too late at that juncture.* (p.61)

In this period, the FOMC composition was hawkish on average. This helped the hawkish Chairman Martin to reach a consensus for tighter policy to act preemptively against inflationary pressures.

6.2 The Vietnam War

In 1965, the U.S. entered the ground war in Vietnam leading to a series of expansionary military spending shocks lasting until 1967Q1. In the FOMC meeting of August 10, 1965, the staff's presentation explicitly accounted for the intended increase of military spending:

> *Further stimulus to the economy will come from expanded Government procurement for Vietnam hostilities. [...] the increases in spending and in the armed forces now proposed do not appear significant enough to touch off [...] widespread price increases. [...] The market response to Vietnam developments doesn't suggest any widespread fears of shortages, rationing, or inflation. On balance, then, the domestic evidence isn't clear enough to me to justify a significant policy move in either direction at this juncture.* (p. 28-29).

Several FOMC members agreed with the staff's assessment and argued for an unchanged policy due to significant uncertainties related to the developments in Vietnam. In contrast, few hawkish FOMC members noted that the Vietnam hostilities were already affecting industrial prices. Two meetings later, on September 28, the dovish members dissented against the "status quo", arguing that, in their judgment, evidence of inflationary pressure was lacking and hence, they preferred an easier policy. In contrast, Alfred Hayes (New York Fed), a hawk, argued in the

[35] The FOMC shifted the emphasis of monetary policy toward slightly less ease and toward maintaining a moderately firm tone in the money market in June 1962, mentioning balance-of-payments concerns. In this period, FOMC members interested in a tighter, inflation-focused monetary policy often cited the balance-of-payments criterion to bolster their case (Bordo and Humpage, 2014).

meeting of October 12, 1965 that: *Looking ahead, I think we have a real basis for concern about potential inflationary pressures* (p.25). Chairman Martin shared similar thinking on inflation while sensing that he did not have a majority to firm policy:

> *While the evidence was not clear, he thought there were many signs of inflation and of inflationary psychology in the economy. [...] But the Committee had a tendency to feel that it was best to wait until all the evidence was in before making a policy change. The difficulty was that when all the evidence was in it was likely to be too late. [...] With a divided Committee and in face of strong Administration opposition he did not believe it would be appropriate for him to lend his support to those who favored a change in policy now.* (p.68-69)

On December 5, 1965, the discount rate was raised with a narrow majority in order to prevent the risk of inflation. However, the tightening signal by the Fed was not enough to contain the buildup of inflationary pressures. While this had become clear for most members, the U.S. President had promised an anti-inflationary fiscal program and the FOMC delayed action in support of promised fiscal restraint. On September 13, 1966, Governor James Robertson summarized the situation as follows: *Inflationary pressures are persisting, as the staff materials have underlined. [...] To counter these inflationary pressures, we now have the promise of help from a somewhat greater degree of fiscal restraint.* (p.72).

Hoping on the legislative action to raise taxes in 1967, by the last quarter of 1966 and throughout the first part of 1967, the FOMC eased policy, despite two large expansionary military spending shocks hitting in 1966Q4 and 1967Q1. In the FOMC meeting of September 12, 1967, Chairman Martin acknowledged that tightening had been delayed for too long because of the tendency to *underestimate the strains being put on economic resources by the hostilities in Vietnam. A "guns and butter" economy was not feasible; the country's resources were not sufficient for that.* (p.73). The FOMC decided to tighten the policy on December 12, 1967. Once again, Chairman Martin admitted delayed action as follows:

> *It was his feeling that the Committee had in a sense been caught in a trap [...] From the standpoint of economic considerations alone, it would have been desirable to adopt a firmer monetary policy a number of months ago.* (p.96)

In the period between 1965 and 1967, the FOMC is categorized as dovish on average. Both, the dovish committee and the political pressure against tighter policy made it more difficult for Chairman Martin to reach a consensus for firm policy within the FOMC. Indeed, we observe that even when the expansionary effects of military spending related to the Vietnam War became evident, the FOMC initially hesitated, then tightened modestly but soon erred toward loose policy.

Overall, the narrative evidence from the 1960s supports the important elements that we highlight in this paper: the Fed's reaction to military spending and the role of the FOMC composition for this reaction.

7 Conclusion

This paper proposes an identification design to estimate the effects of systematic monetary policy for the propagation of macroeconomic shocks. Our design combines the narrative classification of FOMC members' policy preferences from Istrefi (2019) with a novel FOMC rotation instrument for systematic monetary policy. The identification design opens up myriad research opportunities, such as revisiting the effects of various fiscal, technology, and oil shocks and their dependence on systematic monetary policy.

We use our identification design to study government spending shocks and find that fiscal spending multipliers depend strongly and significantly on systematic monetary policy. We inspect the mechanism behind our result and find consistent interest rate and inflation responses. Our results suggest that it is critically important for fiscal policy makers to consider the stance of monetary policy in their decision making process. However, a potentially misleading conclusion from our results is that the government should increase spending when the FOMC is dovish. This could be misleading because such changes in government spending are not random shocks. Moreover, the Lucas (1976) critique applies if the conduct of fiscal policy changes structurally. To avoid such misleading conclusions, a promising avenue for future research is to use our results to discipline micro-founded models to study optimal fiscal stabilization policy.

Finally, while our identification design is specific to U.S. monetary policy, a promising avenue for future research is to study other countries or currency areas in which committees decide monetary policy. In fact, since 2015 the European Central Bank's Governing Council allocates voting rights to its members through a rotation mechanism.

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Appendix A New Keynesian model

A.1 Equilibrium dynamics

We derive equation (2.3). Denoting by lower case letters (log) deviations from steady state, we obtain the following three equilibrium conditions for the model described in Section 2: A New Keynesian Phillips Curve

$$\pi_t = \beta \mathbb{E}_t [\pi_{t+1}] + \lambda \left(\varphi + \frac{1}{1-\gamma} \right) y_t - \frac{\lambda\gamma}{1-\gamma} x_t^s - \lambda(1+\varphi) x_t^a, \tag{A.1}$$

where $\lambda = (1-\theta)(1-\beta\theta)/\theta$, a dynamic IS equation

$$y_t = \mathbb{E}_t [y_{t+1}] - (1-\gamma)(i_t - \mathbb{E}_t [\pi_{t+1}]) + \gamma (1-\rho_s) x_t^s, \tag{A.2}$$

and the Taylor rule

$$i_t = \widetilde{\phi}_t \pi_t, \tag{A.3}$$

where $\widetilde{\phi}_t = \phi + \phi_t$ follows

$$\phi_t = \rho_\phi \phi_{t-1} + \zeta^s \varepsilon_t^s + \zeta^a \varepsilon_t^a + \eta_t, \quad |\rho_\phi| < 1.$$

We assume the macroeconomic shocks $(\varepsilon_t^a, \varepsilon_t^s)$ and the exogenous shifter η_t are mutually independent and identically distributed over time. We first rewrite the IS equation by plugging in the Taylor rule and Phillips Curve to obtain

$$\begin{aligned} y_t = \frac{1-\gamma}{1+\lambda(\varphi(1-\gamma)+1)\phi_t} \Bigg[& \frac{\mathbb{E}_t [y_{t+1}]}{1-\gamma} + (1-\beta\phi_t)\mathbb{E}_t [\pi_{t+1}] \\ & + \frac{\gamma}{1-\gamma} (\phi_t \lambda + (1-\rho_s)) x_t^s + \phi_t \lambda (\varphi+1) x_t^a \Bigg] \end{aligned} \tag{A.4}$$

Combining (A.1) and (A.4), the model dynamics follow $\mathcal{Y}_t = A(\phi_t)\ \mathbb{E}_t [\mathcal{Y}_{t+1}] + B(\phi_t)\ \mathcal{X}_t$, with $\mathcal{Y}_t = (y_t, \pi_t)'$, $\mathcal{X}_t = (x_t^s, x_t^a)'$ and $A(\phi_t), B(\phi_t)$ depending only on model parameters. A first-order approximation around $\phi_t = 0$ yields

$$\mathcal{Y}_t = A\mathbb{E}_t [\mathcal{Y}_{t+1}] + B\mathcal{X}_t + (\partial_{\phi_t} A \mathbb{E}_t [\mathcal{Y}_{t+1}] + A\mathbb{E}_t [\partial_{\phi_t} \mathcal{Y}_{t+1}] + \partial_\phi B \mathcal{X}_t)\phi_t, \tag{A.5}$$

where $A \equiv A(0), B \equiv B(0)$, $\partial_{\phi_t}(\cdot)$ denotes a derivative with respect to ϕ_t that is evaluated at $\phi_t = 0$, and we omit the approximation error. Consider the guess for the law of motion that reads $\mathcal{Y}_t = \mathcal{A} + \mathcal{B}\mathcal{X}_t + \mathcal{C}\mathcal{X}_t\phi_t + \mathcal{D}\phi_t$. It is straightforward to verify that the guess satisfies (A.5). The coefficients of the guess depend on the deep structural parameters of the model and can be determined via the method of undetermined coefficients. This fully describes the approximate state-dependent model dynamics with respect to systematic monetary policy ϕ_t and provides equation (2.3) in the main text, where $a = \mathcal{A}_1,\ b_s = \mathcal{B}_{11},\ b_a = \mathcal{B}_{12}$, and analogously for $\mathcal{C}$ and $\mathcal{D}$. In the special case $\rho_s = \rho_a = \rho_\phi = 0$, the coefficients in (2.3) are given by (2.6).

A.2 Identification

We next describe the identification results in Section 2 in some more detail. The key step is to determine the residual in the state-dependent local projection (2.4). Using (2.2), (2.3), and the laws of motion for x_t^s and x_t^a, we obtain

$$v_{t+h}^h = F^h \cdot z_{t+h}^h,$$

where F^h is a coefficient vector and z_{t+h}^h is the following vector of variables:

$$z_{t+h}^h = \Big[x_{t-1}^s, \{\varepsilon_{t+i}^s\}_{i=1}^h, x_{t-1}^s\phi_{t+h}, \varepsilon_t^s\{\eta_{t+i}\}_{i=1}^h, \varepsilon_t^s\{\varepsilon_{t+i}^s\}_{i=1}^h, \varepsilon_t^s\{\varepsilon_{t+i}^a\}_{i=1}^h,$$
$$\{\varepsilon_{t+i}^s\phi_{t+h}\}_{i=1}^h, \{\eta_{t+i}\}_{i=1}^h, \{\varepsilon_{t+i}^a\}_{i=1}^h, x_{t+h}^a, x_{t+h}^a\phi_{t+h}\Big]',$$

where $\{\varepsilon_{t+i}^s\}_{i=1}^h$ denotes the vector of all ε_{t+i}^s for $i = 1$ through $i = h$, and analogously for all terms in braces. Defining the vector of regressors (excluding the intercept) in (2.4) by

$$X_t = \Big[\varepsilon_t^s,\ \varepsilon_t^s\phi_t,\ \phi_t\Big]',$$

a sufficient condition for the consistency of the OLS estimates of $(\beta^h, \gamma^h, \delta^h)$ requires

$$E[X_t(z_{t+h}^h)'] = \mathbf{0},$$

where $\mathbf{0}$ denotes a zero matrix with conforming dimension. In general, this orthogonality condition is satisfied if $\zeta^s = \zeta^a = 0$.

We next turn to the IV estimator of $(\beta^h, \gamma^h, \delta^h)$. Consider an instrument ϕ_t^{IV} with the following properties:

$$E[\phi_t^{IV}\varepsilon_{t+i}^s] = E[\phi_t^{IV}\varepsilon_{t+i}^a] = 0 \quad \forall i$$
$$E[\phi_t^{IV}\eta_t] \neq 0, \qquad E[\phi_t^{IV}\eta_{t+i}] = 0 \quad \forall i \neq 0$$

Defining as instrument vector

$$Q_t = \Big[\varepsilon_t^s, \varepsilon_t^s\phi_t^{IV}, \phi_t^{IV}\Big]',$$

consistency of the IV estimator requires

$$E[Q_t(z_{t+h}^h)'] = \mathbf{0}.$$

This condition is generally satisfied in our model. Hence, the IV estimator consistently estimates $(\beta^h, \gamma^h, \delta^h)$ even in the absence of strong exogeneity assumptions for systematic monetary policy ϕ_t.

Appendix B Data

This section explains the data sources and data preparation procedures used to compile the data set used in our analysis.

B.1 Narrative account

We use Istrefi's (2019) data set which is a panel of FOMC members where the time dimension refers to FOMC meetings. The panel contains the policy preferences of voting members at each FOMC meeting for 1960-2023. We code the numerical variable $Hawk_{i\tau} \in [-1, 1]$ as explained in the main text.

Accounting for missing data. The information on some FOMC members during the first five years of our sample is relatively sparse, leaving us with many unclassified FOMC members in this period. For example, we observe the preferences for only 115 out of 195 member-meeting pairs in 1960. The share of observed preferences increases gradually. From 1966 onward, we reach an average share of 88 percent which is satisfactory. Before 1966 we employ the following imputation scheme. We assume that the unobserved preferences coincide with the first observed preference of the respective FOMC member. Formally, let $t(i)$ be the first meeting for which $Hawk_{i\tau}$ is not missing for member i. Then, we assume that $Hawk_{i\tau} = Hawk_{it(i)}$ for all $\tau < t(i)$.

Accounting for short-term substitutes. Occasionally, voting FOMC members do not attend the meetings but instead, get replaced by a substitute. This introduces noise in the data under the assumption that the short-term substitutes act in the best interest of the person that is substituted. This assumption is appropriate as the short-term substitutes are often direct subordinates of the original voting member. Thus, we explicitly assume that short-term substitutes act as if the original member attended the meeting if the following criteria hold: (i) the substitution period is not longer than 6 months when the substitute is from the same Federal Reserve bank, (ii) the substitution period is not longer than 3 months if the substitute is not from the same Federal Reserve bank, (iii) the substitution does not take place at the beginning or the end of a rotation cycle within a rotation group.[36] Formally, let $Hawk_{i\tau}$ be the preference of a substitute that appears in meeting τ. Then, we set $Hawk_{i\tau} = Hawk_{j\tau-k}$ where j is the original member and we use the most recent observation of her policy preferences from meeting $\tau - k$. However, many times it holds that the preferences of the substitute and the original voter coincide which implies that the procedure above does not change the data. It turns out that we change less than 1 percent of the data points, and that our results are insensitive to the choices made above.

[36] For example, consider the rotation between the Chicago and Cleveland Federal Reserves. Suppose that the Chicago president had the voting right until meeting τ and the Cleveland president thereafter. If Chicago exercises the voting right in $\tau + 1$ on behalf of Cleveland, we would not conduct any corrections because it is not clear whether the Chicago president acts in the best interest of the Cleveland president or not.

B.2 Macroeconomic data

All aggregate series are explained below. If applicable, we put the data identifiers of the respective data source in parentheses.

Ramey and Zubairy (2018). We take the series for potential output (*rgdp_pott6*), real GDP (*rgdp*), nominal government spending (*ngov*), the GDP deflator (*pgdp*) and the military spending news shock (*news*) from the replication package of Ramey and Zubairy (2018). We follow their data preparation steps to create the aggregate series as in their paper.[37]

FRED Economic Data. We use headline CPI (*CPIAUCSL*) and CPI core (*CPILFESL*) inflation defined as the year-over-year growth rate of the respective price index, and the effective federal funds rate (*DFF*). The 10-year treasury market yield (*DGS10*) starts only in 1962q1 and is therefore combined with the very same variable from Romer and Romer (2010) to obtain a series that starts in 1960q1. Similarly, we use the 1-year market yield from Liu and Wu (2021) and impute the first four observations (1960q1 to 1960q4) with a similar 1-year treasury market yield from Fred (*DTB1YR*). Personal consumption expenditures (*PCE*), gross private domestic investment (*GPDI*), and federal government defense expenditures (*FDEFX*) is divided by the GDP deflator and by real potential GDP, both taken from Ramey and Zubairy (2018), see above. We compute non-military government spending by subtracting the defense spending from total government spending. Variables are averaged to quarterly frequency, if applicable.

Livingston survey. We use inflation expectations from the Livingston survey. Our measure of inflation expectation is the annualized expected growth rate of CPI forecasts from 6 to 12 months ahead. Because the survey is biannual, we assume that inflation expectations remain constant in quarters in which no new data is available. Formally, we let $\pi_t^e = \pi_{t-1}^e$, whenever there is no survey conducted in quarter t. The (ex-ante) real rates are computed as $i_t^r = i_t^n - \pi_t^e$ where i_t^n is a nominal rate of interest.

Additional series. The validation exercise in Appendix E is based on forecasts from the Fed's Greenbook. We use the average of the one- and two-quarter ahead inflation forecast, following Coibion and Gorodnichenko (2011). We use additional series for some exercises in our sensitivity analysis. For the Blanchard and Perotti (2002) shock, we account for anticipation in government spending by including the one-quarter projected growth rate of government spending from Ramey's (2011) data.[38] As an additional control variable we use the primary surplus (*svt_q*) from Cochrane (2022), seasonally adjusted via X-13 ARIMA-SEATS procedure from the U.S. Census Bureau.

[37] The fiscal shock is computed as $news_t/(pgdp_{t-1} \times rgdp\_pott6_{t-1}) \times 100$. Detrended real GDP is $rgdp_t/rgdp\_pott6_t \times 100$ and detrended real government spending is $ngov_t/(pgdp_t \times rgdp\_pott6_t) \times 100$.

[38] The survey of professional forecasters provides the government spending forecasts only from 1981q3 onward. Thus, Ramey (2011) imputes the government spending forecasts with defense spending forecasts to extend the sample until 1968q4.

Appendix C Hawk-Dove decompositions

In this section, we propose a decomposition of fluctuations in the aggregate Hawk-Dove balance $Hawk_t$ and the FOMC rotation instrument $Hawk_t^{IV}$. We find that the FOMC rotation is a key source of variation in $Hawk_t$. Variation in the instrument $Hawk_t^{IV}$ is largely due to the rotation of incumbent FOMC members.

Decomposition of $Hawk_t$. We derive a decomposition of the aggregate Hawk-Dove balance similar to the aggregate productivity decomposition in Baily et al. (1992). We first rewrite the aggregate Hawk-Dove balance in equation (3.2) as

$$Hawk_t = \sum_{i \in \mathcal{M}_t} s_t Hawk_{it}, \quad s_t = \frac{1}{|\mathcal{M}_t|}. \tag{C.1}$$

We define a decomposition over p-period changes in the balance:

$$\Delta^p Hawk_t = Hawk_t - Hawk_{t-p} = \sum_{i \in \mathcal{M}_t} s_t Hawk_{it} - \sum_{i \in \mathcal{M}_{t-p}} s_{t-p} Hawk_{it-p} \tag{C.2}$$

We next partition the set $\mathcal{M}_t$ into the set of "surviving" FOMC members S_t present in $t-p$ and t, the set of entering FOMC members E_t present in t but not in $t-p$, and the set of exiting FOMC members X_t present in $t-p$ but not in t to rewrite:

$$\begin{aligned}\Delta^p Hawk_t &= \sum_{i \in S_t} (s_t Hawk_{it} - s_{t-p} Hawk_{it-p}) + \sum_{i \in E_t} s_t Hawk_{it} - \sum_{i \in X_t} s_{t-p} Hawk_{it-p} \\ &= \sum_{i \in S_t} s_{t-p} (Hawk_{it} - Hawk_{it-p}) + \sum_{i \in S_t} (s_t - s_{t-p}) Hawk_{it} \\ &\quad + \sum_{i \in E_t} s_t Hawk_{it} - \sum_{i \in X_t} s_{t-p} Hawk_{it-p} \end{aligned} \tag{C.3}$$

The first term captures changes in preferences of surviving FOMC members, the second term captures changes in the number of FOMC members, the third term captures entry into the FOMC, and the last term captures exit from the FOMC.

Finally, we further distinguish between the rotating and non-rotating FOMC members in the set of entering and exiting FOMC members, denoted E_t^R, E_t^N, X_t^R and X_t^N to obtain our decomposition of interest:

$$\begin{aligned}\Delta^p Hawk_t = &\sum_{i \in S_t} s_{t-p} (Hawk_{it} - Hawk_{it-p}) + \sum_{i \in S_t} (s_t - s_{t-p}) Hawk_{it} \\ &+ \sum_{i \in E_t^N} s_t Hawk_{it} - \sum_{i \in X_t^N} s_{t-p} Hawk_{it-p} \\ &+ \sum_{i \in E_t^R} s_t Hawk_{it} - \sum_{i \in X_t^R} s_{t-p} Hawk_{it-p} \end{aligned} \tag{C.4}$$

The second row captures changes in the aggregate Hawk-Dove balance due to the entry and exit of rotating FOMC members, while the third row captures the contribution of entry and exit of non-rotating FOMC members.

We use the decomposition of the aggregate Hawk-Dove balance in equation (C.4) to quantify the statistical importance of three factors (corresponding to the three rows of the equation): intensive-margin changes in preferences, extensive margin changes of non-rotating FOMC members, and extensive margin changes due to the rotation. We focus on the yearly changes in the quarterly aggregate Hawk-Dove balance (i.e., we set $p = 4$) to capture well the changes due to the annual rotation.

The variance in yearly changes of the aggregate Hawk-Dove balance is 0.083. The variance of the first term in the first row of (C.4), which captures intensive margin changes of preferences, corresponds to 9% of the total variance. Changes in the weights, the second term in the first row, are negligible in size. The variance of the second row of (C.4), capturing extensive margin changes of non-rotating FOMC members, corresponds to 22% of the total variance. The variance of the third row of (C.4), capturing extensive margin changes of rotating FOMC members, corresponds to 53% of the total variance. Finally, the covariances between these terms account for 15% of the total variance. The results differ little for quarterly changes ($p = 1$). Notably, extensive margin changes of rotating FOMC members still account for 52% of the total variance.

Decomposition of $Hawk_t^{IV}$. Analogously, we propose a decomposition for the FOMC rotation instrument. We first rewrite $Hawk_t^{IV}$ in equation (C.7) as

$$Hawk_t^{IV} = \sum_{i \in \mathcal{R}_t} s_t^R Hawk_{it}, \quad s_t^R = \frac{1}{|\mathcal{R}_t|}. \tag{C.5}$$

After a little algebra, we obtain

$$\begin{aligned} \Delta^p Hawk_t^{IV} = & \sum_{i \in S_t^R} s_{t-p}^R (Hawk_{it} - Hawk_{it-p}) + \sum_{i \in S_t^R} (s_t^R - s_{t-p}^R) Hawk_{it} \\ & + \sum_{i \in E_t^R} s_t^R Hawk_{it} - \sum_{i \in X_t^R} s_{t-p}^R Hawk_{it-p}, \end{aligned} \tag{C.6}$$

where S_t^R denotes the set of surviving rotating FOMC members. Finally, we further distinguish between the rotating entering FOMC members whose appointments start or end (A), i.e., they enter for the first time after their appointment as regional FRB president or appear the last time as such, and incumbent (I) regional FRB presidents, denoted E_t^{RA}, E_t^{RI}, X_t^{RA}, X_t^{RI}:

$$\begin{aligned} \Delta^p Hawk_t^{IV} = & \sum_{i \in S_t^R} s_{t-p}^R (Hawk_{it} - Hawk_{it-p}) + \sum_{i \in S_t^R} (s_t^R - s_{t-p}^R) Hawk_{it} \\ & + \left(\sum_{i \in E_t^{RA}} s_t^R Hawk_{it} - \sum_{i \in X_t^{RA}} s_{t-p}^R Hawk_{it-p} \right) \\ & + \left(\sum_{i \in E_t^{RI}} s_t^R Hawk_{it} - \sum_{i \in X_t^{RI}} s_{t-p}^R Hawk_{it-p} \right) \end{aligned} \tag{C.7}$$

We use the decomposition of the FOMC rotation instrument in equation (C.7) to quantify the statistical importance of three factors (corresponding to the three rows of the equation): intensive-margin changes in preferences, extensive margin changes of rotating FOMC members whose appointment starts or ends, and extensive margin changes of incumbent rotating FOMC members.

For yearly changes in the rotation instrument, we find that 93% of the variance is due to the rotation of incumbent members, while 7% is due to appointments starting or ending. All other variances and covariances are negligible in size. Note that yearly changes mechanically mute the importance of intensive margin changes, because current rotating FOMC members are typically not still FOMC members a year later. Therefore, we also study quarterly changes ($p = 1$). Intensive margin changes now explain 4% of the variance, appointments account for 23%, and rotations of incumbent members account for 71%.

Appointments become relatively more important for $p = 1$ because only every fourth quarter of $\Delta^1 Hawk_t^{IV}$ features a rotation. Compared to $\Delta^4 Hawk_t^{IV}$ for which the rotation affects all quarters, we mechanically lower the importance of rotations and the overall variance for $p = 1$.

Appendix D Relation to monetary policy shocks

In this section, we show how empirically identified monetary policy shocks relate to changes in systematic monetary policy. While the model in Section 2 makes a sharp distinction between systematic monetary policy (ϕ_t) and monetary policy shocks (that would enter the Taylor rule as additive extra terms), empirically identified monetary policy shocks often blur this distinction. We revisit the seminal identification strategy proposed by Romer and Romer (2004), RR henceforth. They identify monetary policy shocks as the residual from a regression of changes in the target federal funds rate on various Greenbook forecasts. To interpret their regression through the lens of our model in Section 2, we consider a stylized version of the RR regression

$$i_t = \phi^{\text{RR}} \pi_t^{\text{GB}} + \varepsilon_t^{\text{RR}}, \tag{D.1}$$

in which π_t^{GB} denotes the Greenbook inflation forecast before a change in monetary policy, and $\varepsilon_t^{\text{RR}}$ is the RR monetary policy shock.[39] For simplicity, we put estimation and identification concerns aside. We further assume the following data-generating policy rule[40]

$$i_t = \phi_t \pi_t^{\text{GB}} + \varepsilon_t^m, \tag{D.2}$$

where ε_t^m is a true monetary policy shock and systematic monetary policy satisfies $\phi_t > 1$. Combining this with the RR regression yields the RR shock

$$\varepsilon_t^{\text{RR}} = (\phi_t - \phi^{\text{RR}}) \pi_t^{\text{GB}} + \varepsilon_t^m. \tag{D.3}$$

Hence, the empirical shock $\varepsilon_t^{\text{RR}}$ captures variation in systematic monetary policy ϕ_t, variation

[39] The stylized regression omits any lags or leads from the original regression in Romer and Romer (2004). This is inconsequential if the DGP features *iid* fluctuations. We further omit unemployment and output growth from the original regression, because they are absent from the policy rule in the model.

[40] For simplicity, we define the Taylor rule over π_t^{GB}, instead of π_t as in Section 2. The insight in this section does not change under the original rule, except that $\varepsilon_t^{\text{RR}}$ also depends on the forecast error $\pi_t^{\text{GB}} - \pi_t$.

in inflation forecasts π_t^{GB}, and monetary policy shocks ε_t^m. The empirical shock captures the model shock $\varepsilon_t^{\text{RR}} = \varepsilon_t^m$ in the special case when systematic monetary policy is time-invariant. In general, the empirical shock also captures joint time-variation in systematic monetary policy ϕ_t and inflation forecasts π_t^{GB}, where the latter naturally depends on the state of the economy. Finally, high-frequency identified monetary policy shocks may reflect changes in systematic monetary policy in a similar fashion (Bauer and Swanson, 2023).[41]

Appendix E Validation exercise

We use the Hawk-Dove balance and the FOMC rotation instrument to estimate the federal funds rate (FFR) response to inflation forecasts as a function of the hawkishness of the FOMC. In support of our identification design, we find that a hawkish FOMC is associated with a more pronounced hike of the federal funds rate in the face of inflationary pressure. We estimate a state-dependent local projection specification that is akin to a forward-looking Taylor rule. Formally, we estimate a set of regressions

$$FFR_{t+h} = \alpha^h + \beta^h \hat{\pi}_t + \gamma^h \hat{\pi}_t (Hawk_t - \overline{Hawk}) + \zeta^h Z_t + v_{t+h}^h, \tag{E.1}$$

for $h = 0, 1, ..., H$, and FFR_{t+h} and $\hat{\pi}_t$ denote the federal funds rate and the average of the one- and two-quarter ahead Greenbook inflation forecast, respectively. The control vector includes four lags of the federal funds rate and the inflation forecast. The data is at a quarterly frequency and the sample runs from 1969 to 2008, due to the availability of inflation forecasts and the reaching of the zero lower bound in 2008.

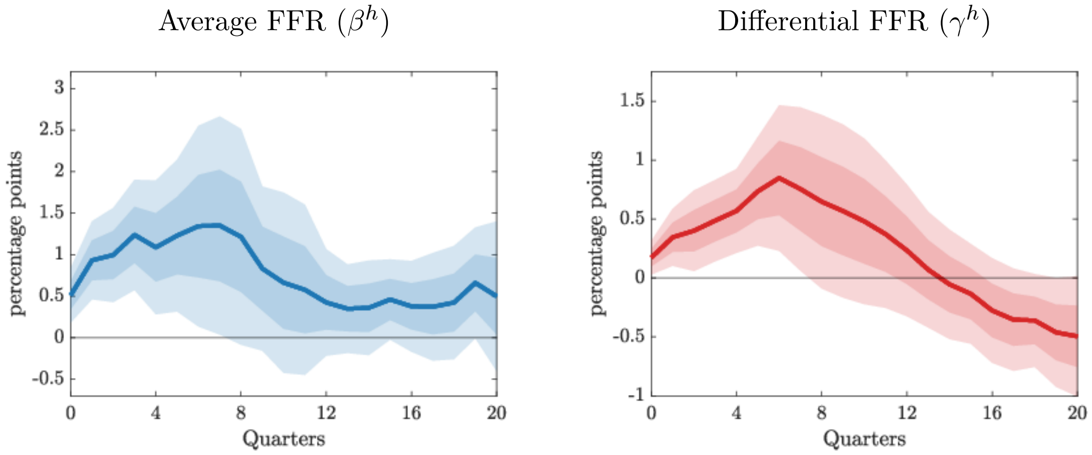
Figure E.1 presents IV estimates where we use the FOMC rotation instrument interacted with the inflation forecast as an instrument for the interaction term in the specification above. We show estimates that are normalized to represent the inflation forecast being one percentage point above the sample average. The left panel displays the response under the average FOMC (β^h). The right panel displays the differential response (γ^h) when there are 2 more hawks in the FOMC relative to the average composition.

On average, the FOMC reacts with a federal funds rate hike. The response is statistically significant at the five percent level for six quarters. The response builds up over time, consistent with interest rate smoothing. Incidentally, it satisfies the Taylor principle for a prolonged period of almost 2 years and peaks at 1.48 percentage points. The response turns stronger when the FOMC is more hawkish, as indicated by the differential effects in Panel (b). The estimates of the interaction coefficient γ^h are hump-shaped and peak after 2 years at 0.92 percentage points. The response is significant at five percent for almost 2 years. This result suggests that a more hawkish FOMC is associated with a stronger and more persistent federal funds rate hike. Conversely, a more dovish FOMC implies a substantially weaker response.

Finally, this validation exercise lends itself to assessing the relevance condition of our instrument

[41] Consider the high-frequency identified monetary policy shock $\varepsilon_t^{\text{HFI}} = i_t - \mathbb{E}_{t-\Delta}[i_t]$, where $\mathbb{E}_{t-\Delta}$ denotes expectations shortly before the meeting. Combining the shock with the monetary policy rule in (D.2) yields $\varepsilon_t^{\text{HFI}} = \varepsilon_t^m + \phi_t \pi_t^{GB} - \mathbb{E}_{t-\Delta}[\phi_t \pi_t^{GB}]$. Hence, $\varepsilon_t^{\text{HFI}}$ convolutes monetary policy shocks ε_t^m with changes in systematic monetary policy ϕ_t and inflation forecasts π_t^{GB}.

Figure E.1: FFR response to inflation and the FOMC hawkishness



Notes: The figure shows responses of the federal funds rate to an inflation Greenbook forecast that is one percentage point above its sample average, conditional on systematic monetary policy ($Hawk_t$). We show IV estimates based on (E.1). The β^h captures the responses when $Hawk_t$ equals its sample average. The γ^h captures the differential responses when $Hawk_t$ exceeds the sample average by two hawks. The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.

more formally. We use the weak instruments test from Montiel Olea and Pflueger (2013).[42] We can reject the null of weak instruments. More formally, we compute p-values for the bias exceeding 10% percent of the benchmark, see Montiel Olea and Pflueger (2013) for details. The p-values are bounded from above by 0.055 and are below the 0.05 level at most horizons. Moreover, for a test of whether the bias exceeds 20%, we can reject the null at 1% for all horizons.

Overall, we show that the federal funds rate response to inflation correlates positively with the hawkishness of the FOMC, $Hawk_t$. The responses are consistent with our measurement of the stance of systematic monetary policy and are further in line with Bordo and Istrefi (2023). We see this result as a validation that our measurement of systematic monetary policy, through $Hawk_t$, captures important aspects of the Federal Reserve's monetary policy-making.

Appendix F Estimating fiscal multipliers

This section elaborates on how we obtain the fiscal multiplier estimate and on how to conduct valid inference.

Cumulated local projection. Summing up equation (3.4) for horizon 0 to H yields

$$\sum_{h=0}^{H} x_{t+j} = \tilde{\alpha}_x^H + \tilde{\beta}_x^H s_t + \tilde{\gamma}_x^H s_t(Hawk_t - \overline{Hawk}) + \tilde{\delta}_x^H (Hawk_t - \overline{Hawk}) + \tilde{\zeta}_x^H Z_t + \tilde{v}_{t+j}^H, \quad \text{(F.1)}$$

where $\tilde{\beta}_x^H = \sum_{h=0}^{H} \beta_x^h$, $\tilde{\gamma}_x^H = \sum_{h=0}^{H} \gamma_x^h$, and analogously for $\tilde{\alpha}_x^H$, $\tilde{\delta}_x^H$, $\tilde{\zeta}_x^H$. The outcome is either cumulated GDP or cumulated government spending (G). With this, one can estimate the

[42] In our setting with a single endogenous regressor, this test is equivalent to the test by Lewis and Mertens (2022).

numerator and the denominator of the fiscal multiplier from equation (4.1) in one step.

One-step multiplier estimation. We employ an estimation procedure akin to seemingly unrelated regressions to estimate equation (F.1) for GDP and G in a single step. This allows us to conduct standard asymptotic inference with respect to the implied fiscal multipliers. First, we define the regressor matrix w and instrument matrix q where each column is a vector of data, i.e. $w_{1\cdot} = (w_{11}, .., w_{1T})'$ and T denotes the sample size.

$$w = (\mathbf{1}, s, s(Hawk - \overline{Hawk}), (Hawk - \overline{Hawk}), Z)' \tag{F.2}$$

$$q = (\mathbf{1}, s, s(Hawk^{IV} - \overline{Hawk}^{IV}), (Hawk^{IV} - \overline{Hawk}^{IV}), Z)' \tag{F.3}$$

The associated vector of coefficients is $\theta^h_x = (\tilde{\alpha}^j_x, \tilde{\beta}^j_x, \tilde{\gamma}^j_x, \tilde{\delta}^j_x, \tilde{\zeta}^j_x)'$. Let us further define $W = \mathbb{I}_2 \otimes w$ and $Q = \mathbb{I}_2 \otimes q$ where $\mathbb{I}_2 \in \mathbb{R}^{2x2}$ denotes the identity matrix. Finally, we define the outcome as $X^h = (Y^h_1, .., Y^h_T, G^h_1, .., G^h_T)' \in \mathbb{R}^{2T\times1}$, where each entry is given by $X^h_t = \sum_{j=0}^h x_{t+j}$, and Y, G refer to GDP and government spending respectively. The instrumental variable estimate of $\Theta^h = (\theta^h_Y{}', \theta^h_G{}')'$ follows from the standard formula,

$$\hat{\Theta}^h = (Q'W)^{-1}Q'X^h. \tag{F.4}$$

We use Driscoll-Kraay standard errors to allow for serial correlation and cross-correlation between cumulated GDP and cumulated government spending. The multiplier estimate is a non-linear function of the estimate $\hat{\Theta}^h$. Standard errors can be computed with the delta method as the above estimation procedure allows to compute an estimate of the full covariance matrix.[43]

Discussion. This procedure has an important advantage compared with the one-step estimation procedure used by Ramey and Zubairy (2018). It admits multiplier estimation in one step without using the fiscal shocks as an instrument for (cumulated) government spending. This is important as Ramey and Zubairy (2018) have to use both the military spending shock and the Blanchard-Perotti shock to obtain a sufficiently strong instrument. Thus, their multiplier estimates do not only hinge on the exogeneity assumption for the military shocks but also on the exogeneity assumption for the Blanchard-Perotti shock. Our approach remains valid even in samples in which the military spending shock has less explanatory power for government spending. This is crucial when working with the military spending shocks in a sample that starts after the Korean War (Ramey, 2011).

Appendix G Additional results for Section 4

This appendix contains additional findings discussed in the main text as well as the results of our sensitivity analysis.

[43] Note that the point estimates are identical to the natural plug-in estimator that one obtains when estimating (F.1) in two-separate regressions.

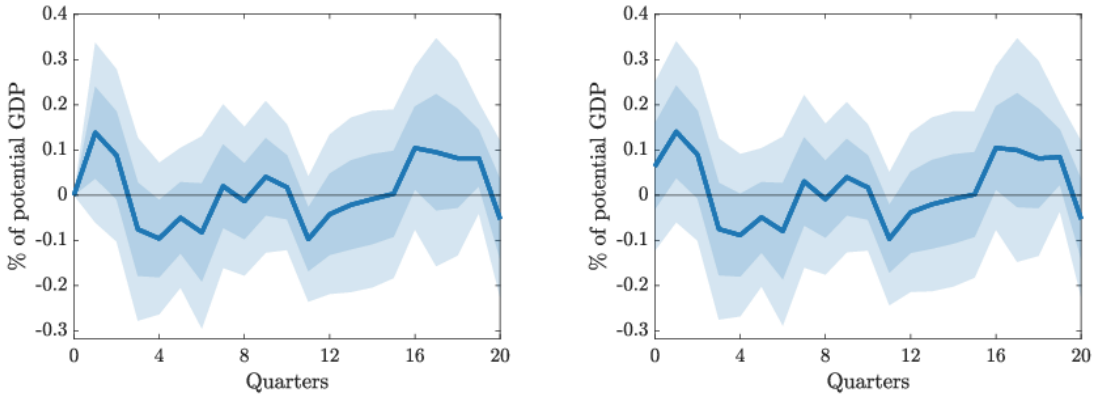
Table G.1: Responses of GDP and government spending, incl. first-stage

	GDP responses				**G responses**				**First-stage results**	
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ε_t^s	0.142	0.166	0.185	0.283	0.092	0.140	0.157	0.152	0.050	0.010
	(0.096)	(0.095)	(0.085)	(0.130)	(0.047)	(0.056)	(0.051)	(0.054)	(0.039)	(0.007)
$\varepsilon_t^s(Hawk_t - \overline{Hawk_t})$	-1.672	-3.099	-2.485	-0.873	-0.342	-0.401	-0.030	0.220		
	(0.775)	(0.841)	(1.433)	(1.174)	(0.209)	(0.258)	(0.416)	(0.653)		
$Hawk_t - \overline{Hawk_t}$	-2.770	-3.698	-4.247	-4.562	-0.593	-0.985	-1.389	-0.948		
	(1.220)	(1.728)	(2.216)	(2.217)	(0.322)	(0.650)	(1.020)	(1.135)		
$\varepsilon_t^s(Hawk_t^{IV} - \overline{Hawk_t}^{IV})$									0.290	-0.019
									(0.053)	(0.021)
$Hawk_t^{IV} - \overline{Hawk_t}^{IV}$									-0.008	0.402
									(0.017)	(0.042)
ε_{t-1}^s	0.024	0.057	0.086	0.245	0.044	0.076	0.092	0.124	0.007	0.011
	(0.157)	(0.216)	(0.221)	(0.153)	(0.033)	(0.046)	(0.043)	(0.043)	(0.003)	(0.006)
ε_{t-2}^s	0.110	0.035	0.078	0.150	0.032	0.052	0.063	0.092	-0.012	0.007
	(0.125)	(0.185)	(0.205)	(0.160)	(0.030)	(0.030)	(0.041)	(0.049)	(0.011)	(0.008)
ε_{t-3}^s	0.045	0.036	0.126	0.188	0.038	0.036	0.037	0.073	-0.000	0.008
	(0.149)	(0.163)	(0.153)	(0.144)	(0.018)	(0.028)	(0.045)	(0.052)	(0.006)	(0.008)
ε_{t-4}^s	0.001	0.033	0.152	0.224	0.023	0.037	0.060	0.139	-0.018	0.004
	(0.141)	(0.125)	(0.117)	(0.144)	(0.022)	(0.027)	(0.041)	(0.038)	(0.012)	(0.010)
GDP_{t-1}	1.314	0.777	0.424	0.037	0.033	0.103	0.135	0.124	-0.000	-0.012
	(0.182)	(0.243)	(0.252)	(0.282)	(0.053)	(0.075)	(0.100)	(0.121)	(0.013)	(0.017)
GDP_{t-2}	-0.406	-0.166	-0.110	0.149	0.006	0.060	0.035	0.039	-0.016	0.013
	(0.190)	(0.209)	(0.159)	(0.197)	(0.054)	(0.072)	(0.077)	(0.094)	(0.020)	(0.014)
GDP_{t-3}	-0.240	-0.012	-0.093	0.081	0.062	0.034	0.044	0.084	0.004	-0.005
	(0.203)	(0.180)	(0.223)	(0.171)	(0.055)	(0.068)	(0.068)	(0.062)	(0.016)	(0.010)
GDP_{t-4}	-0.164	-0.440	-0.284	-0.444	-0.103	-0.218	-0.279	-0.355	0.003	-0.026
	(0.183)	(0.267)	(0.313)	(0.333)	(0.051)	(0.095)	(0.138)	(0.167)	(0.007)	(0.011)
G_{t-1}	-0.639	0.012	0.336	0.864	1.340	1.311	1.121	1.138	0.028	-0.073
	(0.714)	(1.012)	(0.909)	(0.940)	(0.195)	(0.241)	(0.308)	(0.387)	(0.022)	(0.055)
G_{t-2}	1.177	0.596	0.194	-0.223	0.008	-0.042	0.078	0.097	0.008	0.062
	(0.617)	(0.734)	(0.602)	(0.479)	(0.195)	(0.220)	(0.277)	(0.278)	(0.039)	(0.047)
G_{t-3}	-0.391	-0.347	-0.233	-0.519	-0.079	-0.106	-0.136	-0.138	0.017	-0.091
	(0.651)	(0.706)	(0.618)	(0.491)	(0.203)	(0.248)	(0.273)	(0.272)	(0.054)	(0.042)
G_{t-4}	0.022	0.020	0.018	0.162	-0.346	-0.308	-0.268	-0.343	-0.039	0.140
	(0.920)	(0.911)	(0.888)	(0.791)	(0.202)	(0.314)	(0.437)	(0.486)	(0.049)	(0.060)
Observations	196	196	196	196	196	196	196	196	196	196
R^2	0.577	0.347	0.201	0.138	0.934	0.843	0.730	0.646	0.452	0.547
R^2 excl. IVs									0.036	0.154
F-statistic	16.398	4.243	3.418	2.630	94.688	22.683	11.316	15.287	43.691	28.077
F-statistic excl. IVs									4.935	5.804

Notes: The table shows responses of real GDP and real government spending (G) to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. Columns (1) to (4) and (5) to (8) display the one, two, three, and four-year ahead responses, respectively. Regressor ε_t^s captures the responses when $Hawk_t$ equals its sample average and $\varepsilon_t^s(Hawk_t - \overline{Hawk_t})$ captures the differential responses. Columns (9) and (10) display the first-stage results for $\varepsilon_t^s(Hawk_t - \overline{Hawk_t})$ and $(Hawk_t - \overline{Hawk_t})$, respectively. The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.

Figure G.1: Responses of military spending shocks to systematic monetary policy

(a) Baseline model (δ^h) | (b) Linear model (δ^h)



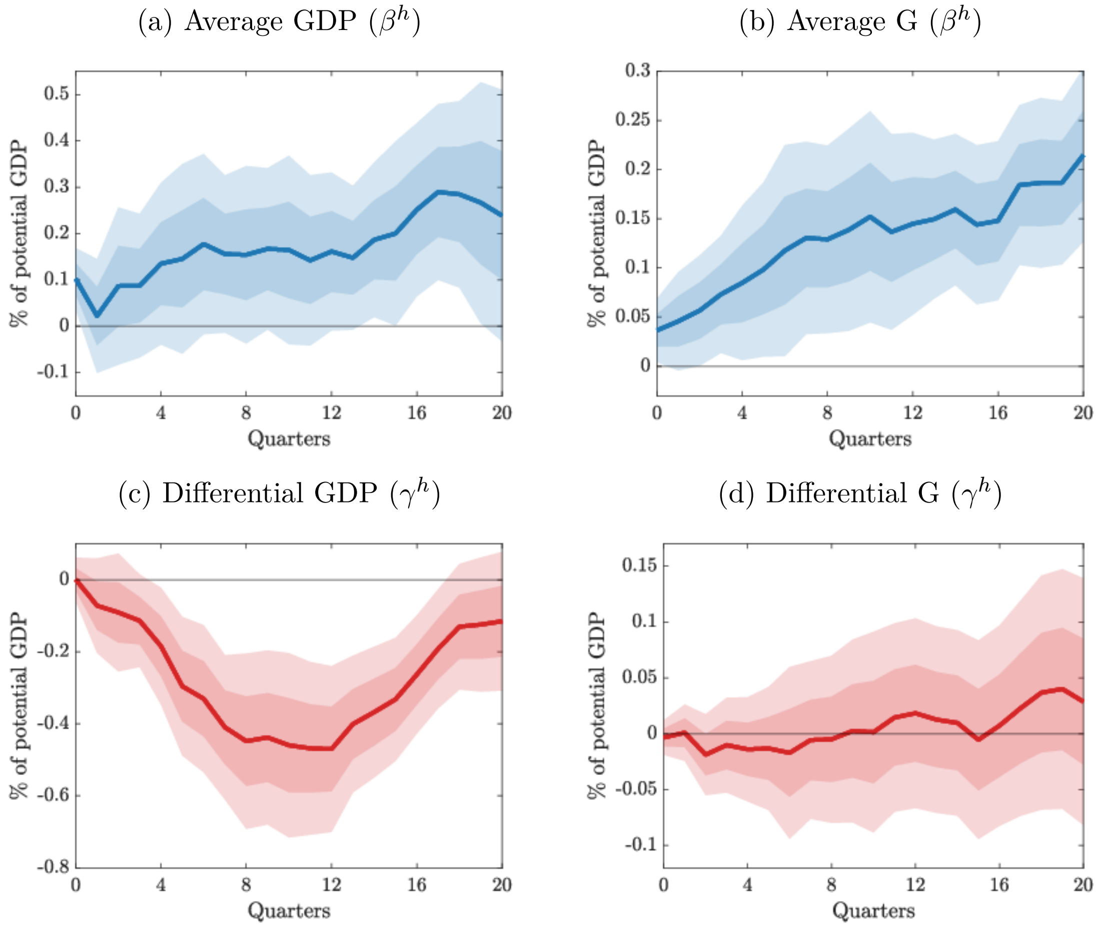
Notes: The figure shows responses of the military spending shock to systematic monetary policy ($Hawk_t$). We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The δ^h captures the differential response when $Hawk_t$ exceeds the sample average by two hawks. Panel (a) shows the results for our baseline model whereas Panel (b) shows the results when we restrict $\beta^h = \gamma^h = 0$ in the local projection (3.4). The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.

Table G.2: Testing for differences across regimes, p-values

Outcome	+2 Hawk vs. Average	+1 Hawks vs. Average	Average vs. +1 Dove	Average vs. +2 Doves
	Two-year horizon			
Multiplier	0.223	0.119	0.102	0.104
GDP (*cum*)	0.000			
G (*cum*)	0.080			
	Four-year horizon			
Multiplier	0.245	0.122	0.041	0.041
GDP (*cum*)	0.008			
G (*cum*)	0.448			

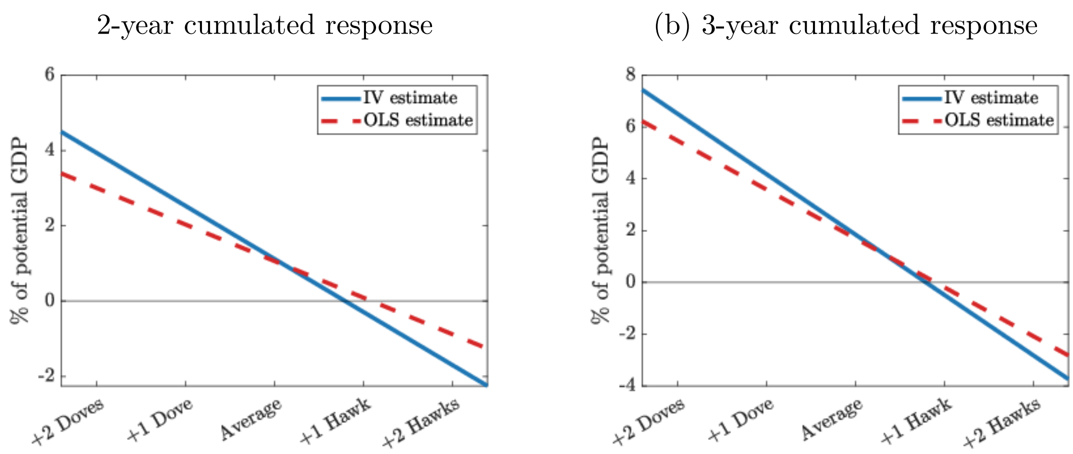
Notes: The table shows p-values corresponding to statistical tests for whether the fiscal multiplier or its components are significantly different across monetary regimes ($Hawk_t$). The tests are based on the multiplier estimates reported in Table 2 in Section 4.4, using Driscoll-Kraay standard errors, see Appendix F for details.

Figure G.2: Responses of GDP and government spending, OLS



Notes: The figure shows responses of real GDP and real government spending (G) to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show OLS estimates based on the local projection framework (3.4) as specified in Section 4.1. The β^h captures the responses when $Hawk_t$ equals its sample average. The γ^h captures the differential responses when $Hawk_t$ exceeds the sample average by two hawks. The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.

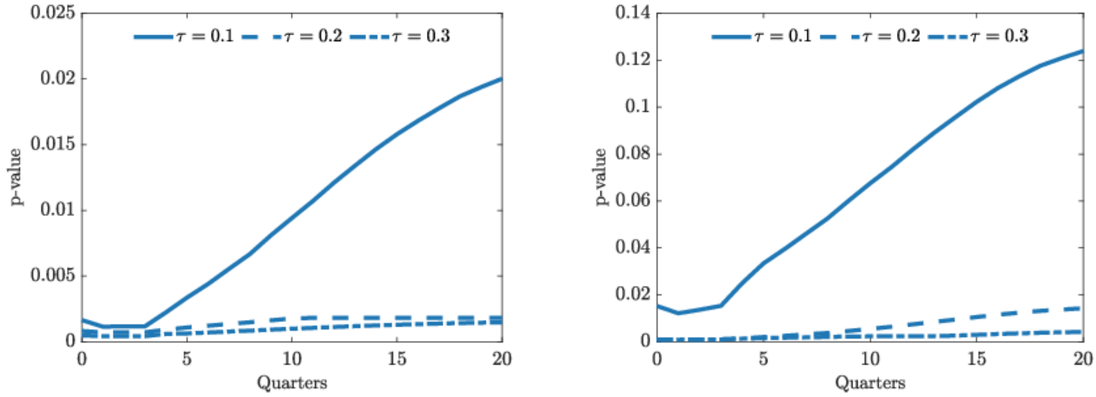
Figure G.3: Cumulated GDP responses for OLS and IV



Notes: The figure shows the cumulative real GDP response to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show IV and OLS estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The displayed estimates are computed as $\sum_{h=0}^{H}[\beta^h + \gamma^h(Hawk_t - \overline{Hawk_t})]$ for $H = 8$ quarters (Panel a) and $H = 12$ quarters (Panel b).

Figure G.4: Weak instrument tests

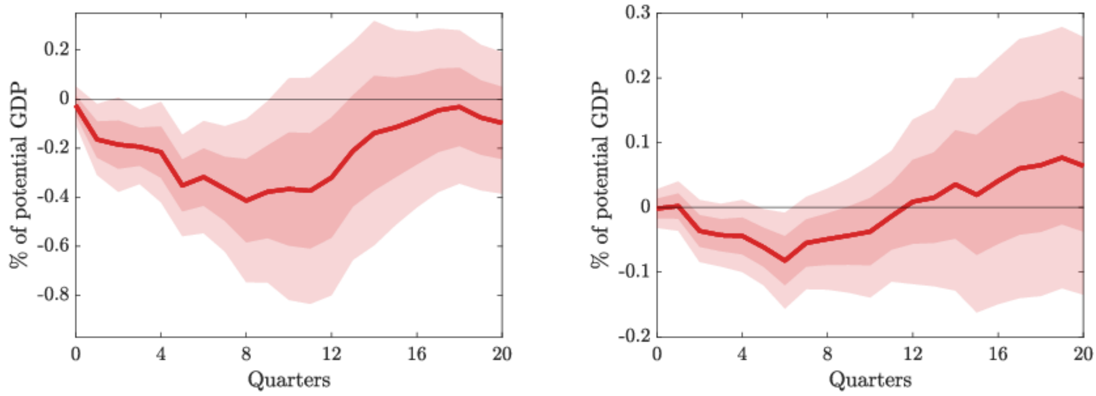
(a) Montiel Olea and Pflueger (2013) (b) Lewis and Mertens (2022)



Notes: The figure shows p-values for rejecting the null of weak instruments for the responses of real government spending (G), based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The Montiel Olea and Pflueger (2013) test evaluates the null of the bias in γ^h exceeding a threshold τ. Similarly, the Lewis and Mertens (2022) test evaluates the null of the ℓ^2 norm of the bias in γ^h and δ^h exceeding a threshold τ. For the former, the endogenous regressor $Hawk_t$ is not tested but directly replaced by its first stage fitted value. The critical values and associated p-values are based on Newey-West standard errors.

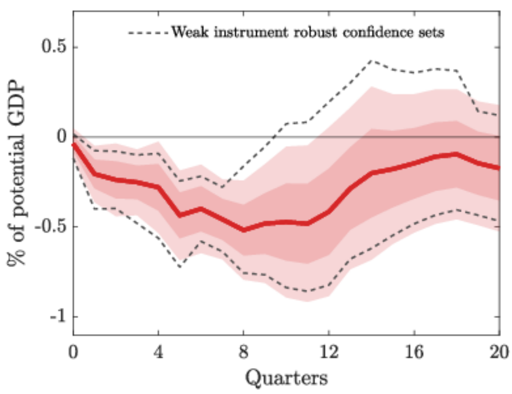
Figure G.5: Differential responses of GDP and government spending, reduced-form

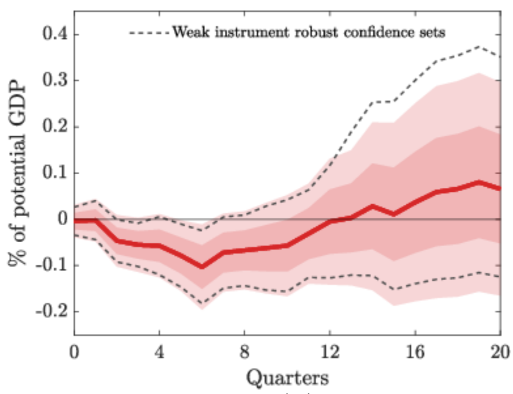
(a) Differential GDP (γ^h) (b) Differential G (γ^h)



Notes: The figure shows differential responses of real GDP and real government spending (G) to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show reduced-form estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The γ^h captures the differential responses when $Hawk_t$ exceeds the sample average by two hawks. Moreover, testing whether γ^h is statistically significant from zero is equivalent to testing for zero relevance of the instrument, as explained in the main text. The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.

Figure G.6: Responses of GDP and government spending, robust inference





Notes: The figure shows differential responses of real GDP and real government spending (G) to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The γ^h captures the differential responses when $Hawk_t$ exceeds the sample average by two hawks. The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors. The dashed bands provide 95% confidence sets, robust to weak identification based on Andrews (2018), constructed via the refined projection method from Chaudhuri and Zivot (2011).

Table G.3: Cumulative 4-year government spending multipliers, Robustness

Specification	Multipliers across regimes			p-values for differences across regimes		
	+2 Hawks	Average	+2 Doves	+2 Hawks vs. +2 Doves	+2 Hawks vs. Average	Average vs. +2 Doves
Baseline	-1.790 (2.637)	1.308 (0.475)	3.095 (1.162)	0.122	0.245	0.041
BP shock	0.880 (1.062)	1.359 (0.837)	1.735 (0.698)	0.082	0.096	0.068
Aggregation schemes						
Median	0.421 (0.568)	1.412 (0.543)	2.225 (0.811)	0.043	0.065	0.036
Chair weight	-1.676 (2.223)	1.531 (0.661)	3.462 (1.514)	0.070	0.175	0.077
Swinger weight	-1.599 (2.165)	1.260 (0.551)	3.037 (1.138)	0.090	0.179	0.043
Drop swingers from IV	0.227 (2.262)	1.590 (0.978)	4.069 (3.113)	0.113	0.531	0.380
Accounting for trends						
5-year MA	-10.655 (53.169)	1.206 (1.177)	3.551 (1.966)	0.792	0.821	0.220
10-year MA	-4.799 (10.138)	0.779 (0.877)	3.049 (1.162)	0.452	0.556	0.092
15-year MA	-2.114 (3.010)	0.931 (0.426)	2.822 (0.869)	0.146	0.277	0.036
Accounting for the ZLB						
End sample '08	-2.002 (2.672)	1.299 (0.510)	3.088 (1.133)	0.108	0.225	0.032
End sample '07	-3.380 (4.499)	0.911 (0.527)	3.005 (1.132)	0.203	0.343	0.031

(Table continues on the next page)

Table G.3 (continued): Cumulative 4-year government spending multipliers, Robustness

	Multipliers across regimes			p-values for differences across regimes		
Specification	+2 Hawks	Average	+2 Doves	+2 Hawks vs. +2 Doves	+2 Hawks vs. Average	Average vs. +2 Doves
Additional controls						
Interest rates	0.388 (1.272)	1.251 (0.688)	1.848 (0.755)	0.306	0.327	0.354
Interest rates, inflation	0.743 (0.873)	1.254 (0.646)	2.033 (1.038)	0.335	0.315	0.386
Interest rates, inflation, surplus	0.661 (1.111)	1.317 (0.855)	2.188 (1.425)	0.379	0.335	0.467
Non-linear controls						
in t	-1.043 (2.657)	1.414 (0.554)	2.813 (1.132)	0.208	0.357	0.068
in $t, ..., t-4$	0.333 (2.298)	2.004 (0.637)	3.022 (1.154)	0.340	0.483	0.137

Notes: The table shows IV estimates of the cumulative fiscal spending multipliers $FM^H(\chi)$ in equation (4.1) for $H = 16$ quarters. The last three columns show p-values corresponding to statistical tests for whether the fiscal multiplier is significantly different across monetary regimes ($Hawk_t$). The baseline coefficients are estimated using a cumulative version of the local projection framework (3.4)-(3.5) as specified in Section 4.1. The columns present different states of the Hawk-Dove balance between "+2 Hawks" ($\chi = +2/12$), "Average" ($\chi = 0$), and "+2 Doves" ($\chi = -2/12$). Driscoll-Kraay standard errors are in parenthesis, see Appendix F for details. BP shock: The shock is contemporaneous G, conditional on controls that include four lags of real GDP and real government spending, as well as the projected growth rate of real government spending. The projected growth rate is taken from the Survey of Professional Forecasters and is available from 1969 onward, which is the start of our sample, see Appendix B. Aggregation schemes: We use three variants of $Hawk_t$. Median: We aggregate the cross-section of FOMC members by the median, instead of the arithmetic average. Chair weight: We assign the preferences of the Fed Chair twice the weight of an ordinary member when aggregating to $Hawk_t$. Swinger weight: We do not discriminate between swingers and consistent members. Finally, we use an alternative definition of the instrumental variable $Hawk_t^{IV}$ by setting swingers to zero before aggregating to a time series. Accounting for trends: We use three variants of $Hawk_t$ where we subtract the backward-looking 5, 10, or 15-year moving average from $Hawk_t$ prior estimation. Accounting for the ZLB: We use a sub-sample that ends either in 2008Q4 or 2007Q4 to exclude the ZLB, or both the ZLB and the Great Recession. Additional controls: We augment the control vector Z_t gradually by four lags of treasury yields with 1-year and 10-year maturity, the fed funds rate (interest rates), CPI inflation, and the primary surplus from Cochrane (2022). Non-linear controls: We augment the control vector Z_t by interacting the baseline control vector also with $Hawk_t$ and instrument these controls accordingly (in t). We further augment the control vector by including and instrumenting lagged interaction terms, i.e. $Hawk_{t-i} \times C_{t-i}$ with $i = 1, ..., 4$ and C_t referring to G, GDP, and ε_t^s (in $t, ..., t-4$).

Table G.4: Cumulative 4-year government spending multipliers, Discrete Hawk-Dove balance

	Multipliers across regimes			p-values for differences across regimes		
Specification	Hawkish	Average	Dovish	Hawkish vs. Dovish	Hawkish vs. Average	Average vs. Dovish
Quartiles	-6.002 (10.343)	1.727 (0.775)	4.814 (2.774)	0.264	0.460	0.201
Tertiles	-3.481 (6.227)	0.490 (0.772)	2.835 (1.083)	0.336	0.488	0.047

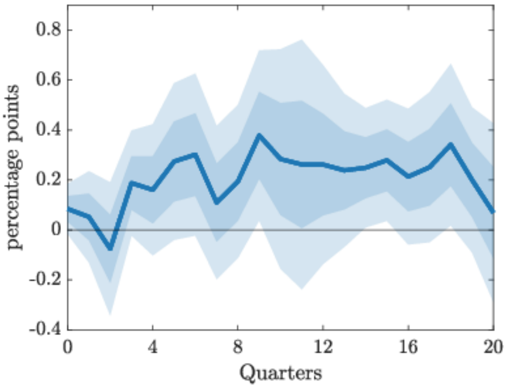
Notes: The table shows IV estimates of the cumulative fiscal spending multipliers $FM^H(\chi)$ in equation (4.1) for $H = 16$ quarters. The last three columns show p-values corresponding to statistical tests for whether the fiscal multiplier is significantly different across monetary regimes ($Hawk_t$). The coefficients are estimated using a cumulative version of the local projection framework (3.4)-(3.5) as specified in Section 4.1. We use two discrete variants of $Hawk_t$. We define that the discrete $Hawk_t$ equals -1 if $Hawk_t$ falls below the first quartile or tertile of the distribution of $Hawk_t$ over time, +1 if above the highest quartile or tertile, and zero else. The columns present different states of the Hawk-Dove balance between "Hawkish" (χ within the last quartile or tertile), "Average" (χ between the first and last quartile or tertile) "Dovish" (χ within the first quartile or tertile).

Appendix H Additional results for Section 5

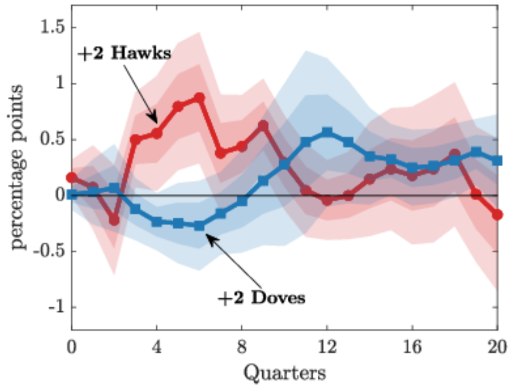
This appendix contains additional findings discussed in the main text.

Figure H.1: Responses of nominal interest rates, omit shocks at end of rotation cycle

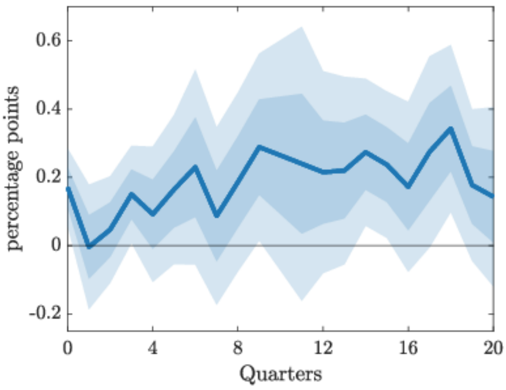
(a) Average FFR (β^h)



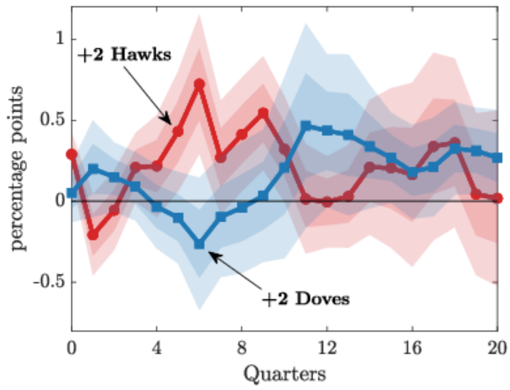
(b) State-dependent FFR ($\beta^h \pm \gamma^h$)



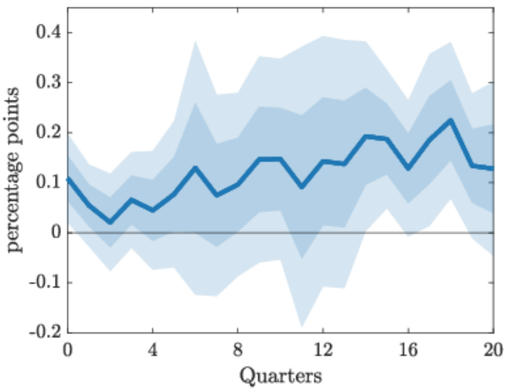
(c) Average 1-year rate (β^h)



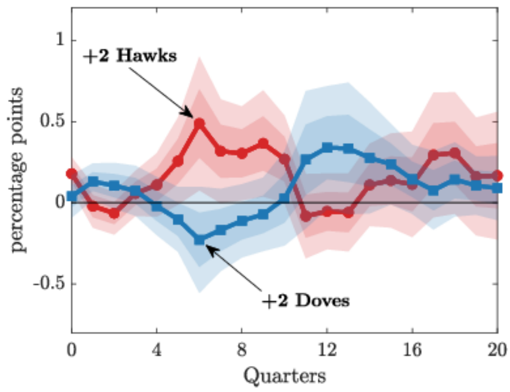
(d) State-dependent 1-year rate ($\beta^h \pm \gamma^h$)



(e) Average 10-year rate (β^h)

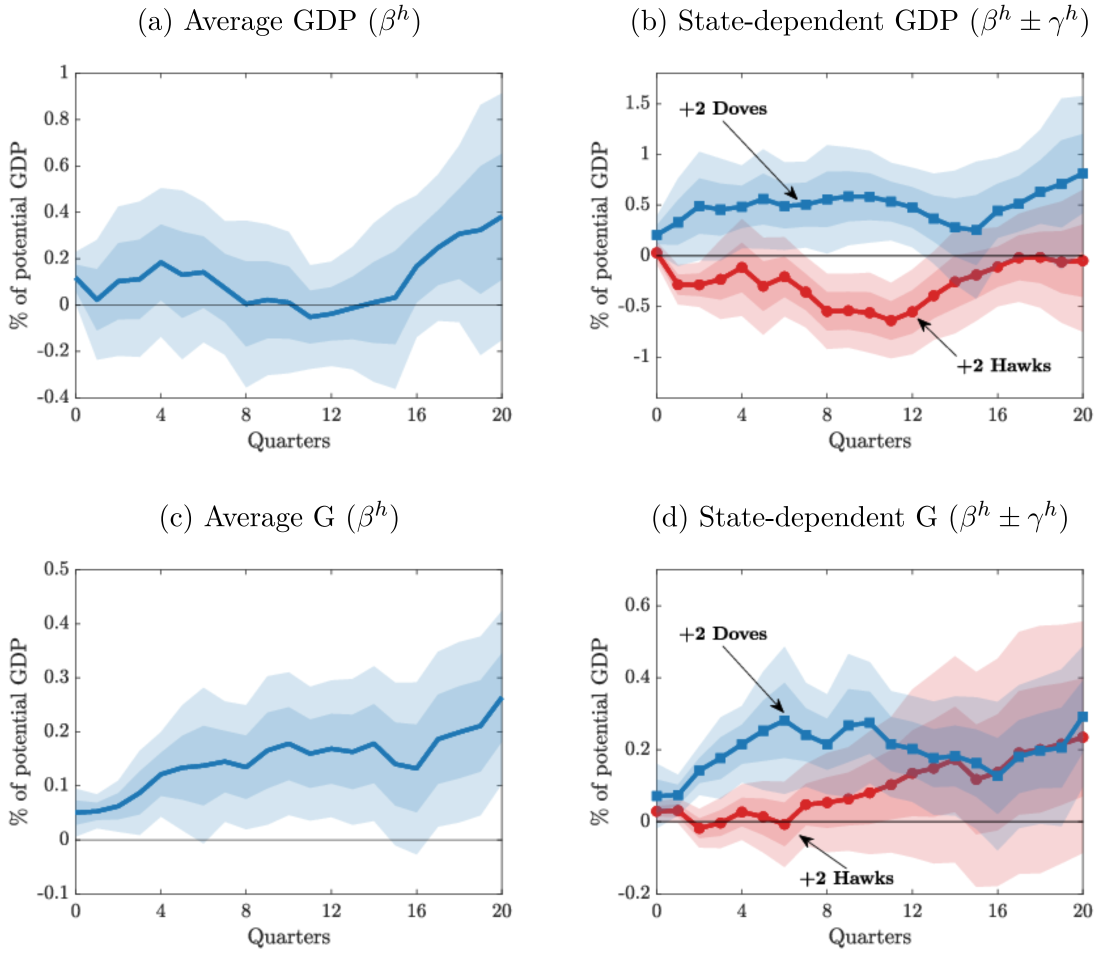


(f) State-dependent 10-year rate ($\beta^h \pm \gamma^h$)



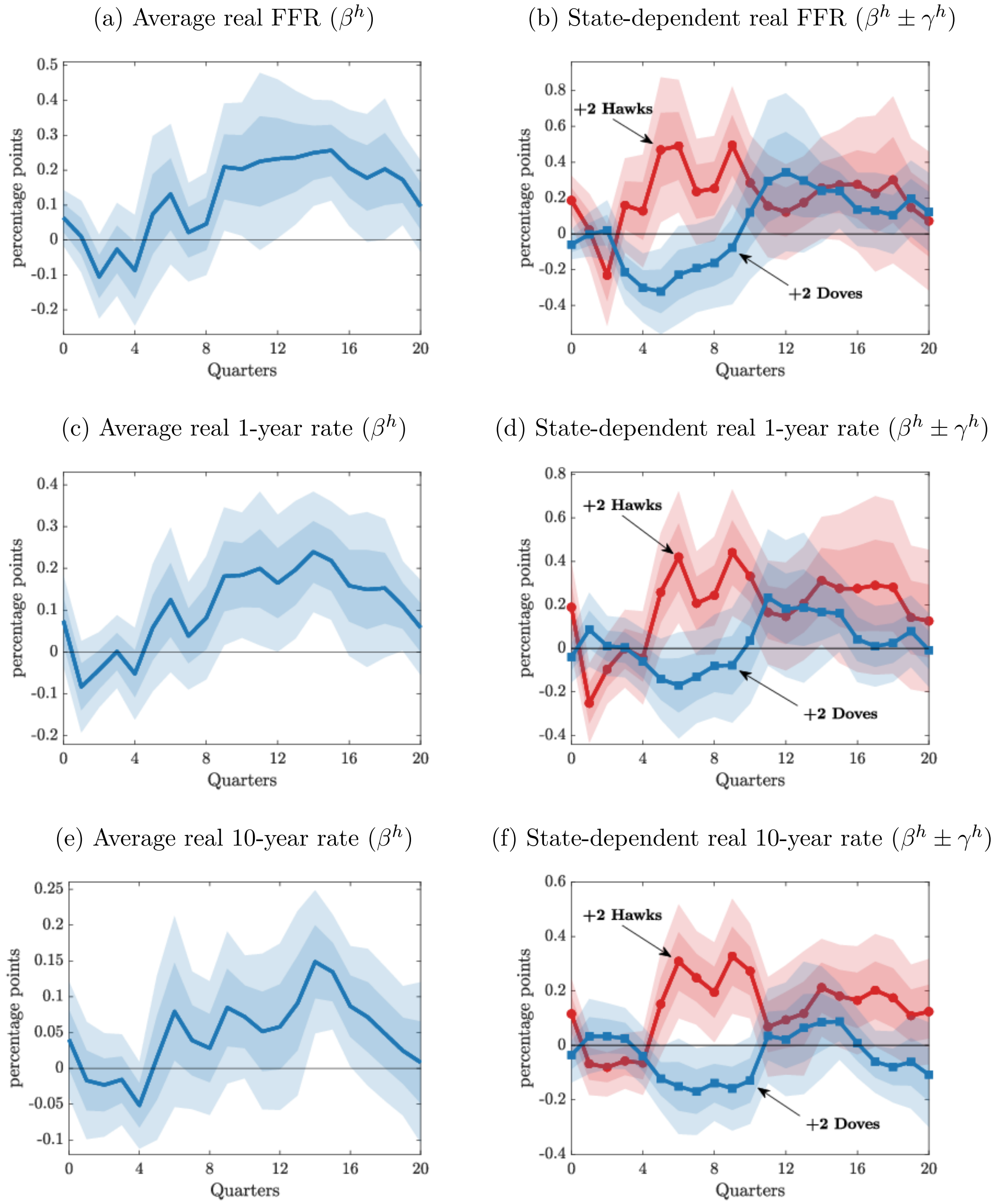
Notes: The figure shows responses of the federal funds rate (FFR), as well as the 1-year and 10-year treasury yields to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). All outcomes are annualized interest rates. We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 5.1. The β^h captures the responses when $Hawk_t$ equals its sample average. The $\beta^h \pm \gamma^h$ shows the state-dependent responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors. We set the military spending shocks occurring in Q3 or Q4 to zero.

Figure H.2: Responses of GDP and government spending, omit shocks at end of rotation cycle



Notes: The figure shows responses of real GDP and real government spending (G) to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The β^h captures the responses when $Hawk_t$ equals its sample average. The $\beta^h \pm \gamma^h$ shows the state-dependent responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors. We set the military spending shocks occurring in Q3 or Q4 to zero.

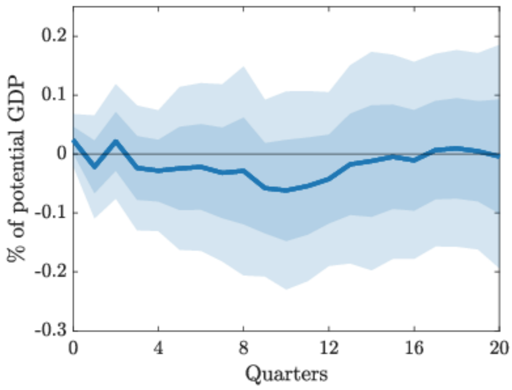
Figure H.3: Responses of real interest rates



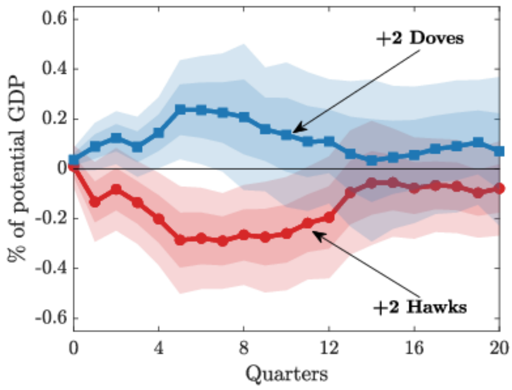
Notes: The figure shows responses of the real federal funds rate (FFR), as well as the 1-year and 10-year real treasury yields to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 5.1. All outcomes are annualized ex-ante real interest rates which we compute as nominal rate minus one-year ahead inflation expectations according to the Livingston Survey, see Appendix B for details. The β^h captures the responses when $Hawk_t$ equals its sample average. The $\beta^h \pm \gamma^h$ shows the state-dependent responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors.

Figure H.4: Decomposing the GDP response, private spending

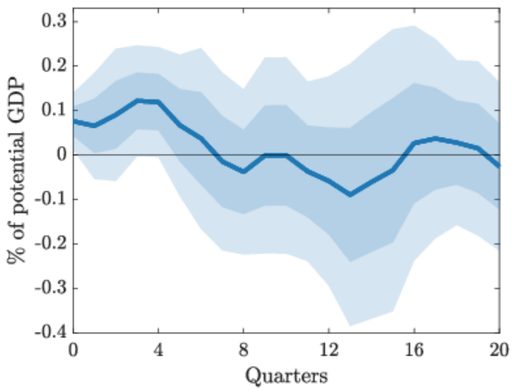
(a) Average consumption (β^h)



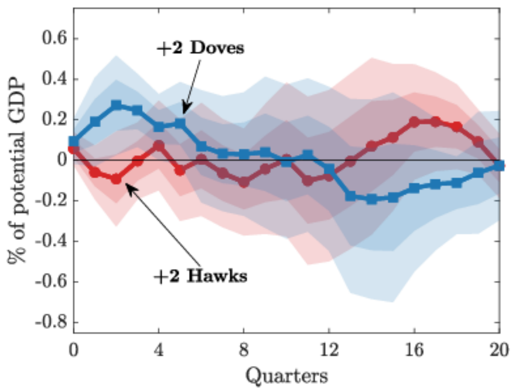
(b) State-dependent consumption ($\beta^h \pm \gamma^h$)



(c) Average investment (β^h)



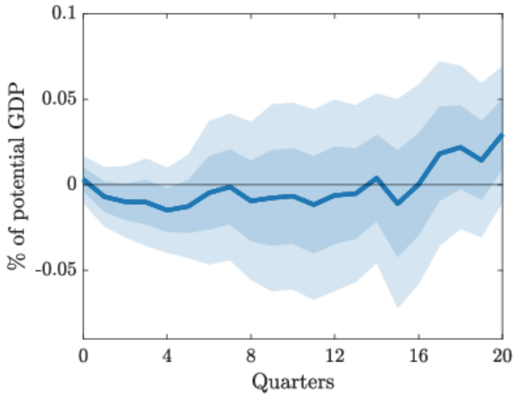
(d) State-dependent investment ($\beta^h \pm \gamma^h$)



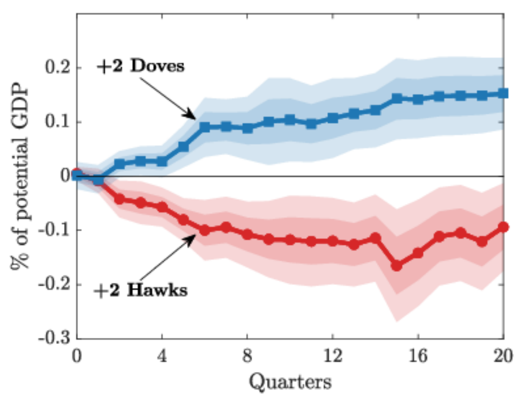
Notes: The figure shows responses of real private consumption and real private investment to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The β^h captures the responses when $Hawk_t$ equals its sample average. The $\beta^h \pm \gamma^h$ shows the state-dependent responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors. We modify the control vector to include four lags of consumption, investment, and government spending, as well as the shock and a residual component of GDP, which we compute as GDP minus consumption, investment, and government spending.

Figure H.5: Decomposing the GDP response, government spending

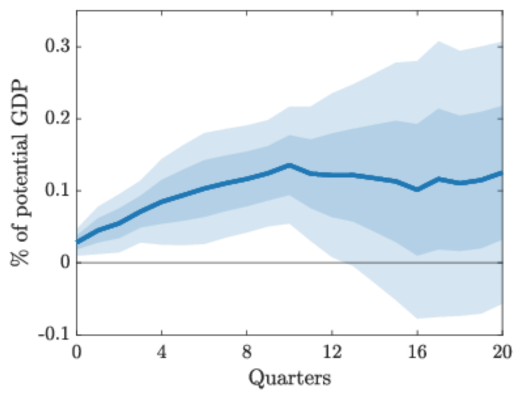
(a) Average non-military G (β^h)



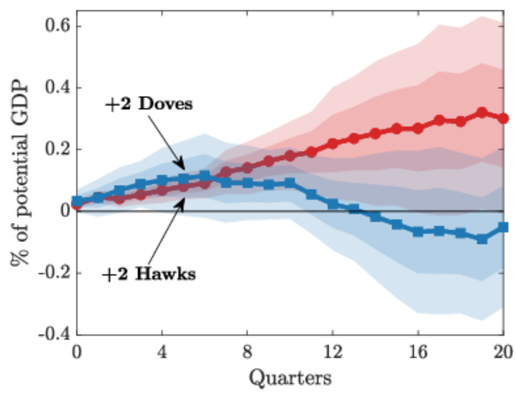
(b) State-dependent non-military G ($\beta^h \pm \gamma^h$)



(c) Average military G (β^h)



(d) State-dependent military G ($\beta^h \pm \gamma^h$)



Notes: The figure shows responses of real government spending (for military and non-military purposes) to an expansionary military spending shock, corresponding to one percent of GDP, conditional on systematic monetary policy ($Hawk_t$). We show IV estimates based on the local projection framework (3.4)-(3.5) as specified in Section 4.1. The β^h captures the responses when $Hawk_t$ equals its sample average. The $\beta^h \pm \gamma^h$ shows the state-dependent responses when $Hawk_t$ exceeds the sample average either by two hawks (+2 Hawks) or by two doves (+2 Doves). The shaded areas indicate 68% and 95% confidence bands using Newey-West standard errors. We modify the control vector to include four lags of military and non-military government spending as well as the shock and real GDP.

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