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Integrating balance sheet policy into monetary policy conditions[*]

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Abstract

This paper introduces a new Monetary Policy Conditions Index (MCI) that integrates conventional and unconventional monetary policy tools into a unified measure. The MCI is a weighted average of short-term interest rate and central bank balance sheet size, improving upon the shadow rate by capturing balance sheet policy effects away from the effective lower bound. We estimate the MCI's weight and its dynamic relationships with output, inflation and financial conditions using a Bayesian Vector Autoregression (BVAR) framework. Results suggest that large balance sheet policies have exerted a significant accommodative influence on monetary policy conditions, including away from the effective lower bound. Through historical decomposition and counterfactual exercises, the MCI provides new insights into unconventional policy's effectiveness and unintended consequences. The framework can flexibly accommodate numerous extensions, including possibly higher neutral balance sheet under ample reserve system.

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1 Introduction

The rise of inflation targeting regime in the 1990s brought a broad convergence of what central banks target and with what tools. Policy interest rate, typically the overnight or very short-term interest rate, became the main policy instrument of choice. While the Federal Reserve did not formally adopt an inflation target until 2012, it had been setting explicit targets for the fed funds rate, the overnight interest rate on funds held by banks and other financial institutions in accounts at the Fed, as part of its monetary policy framework since the 1970s.

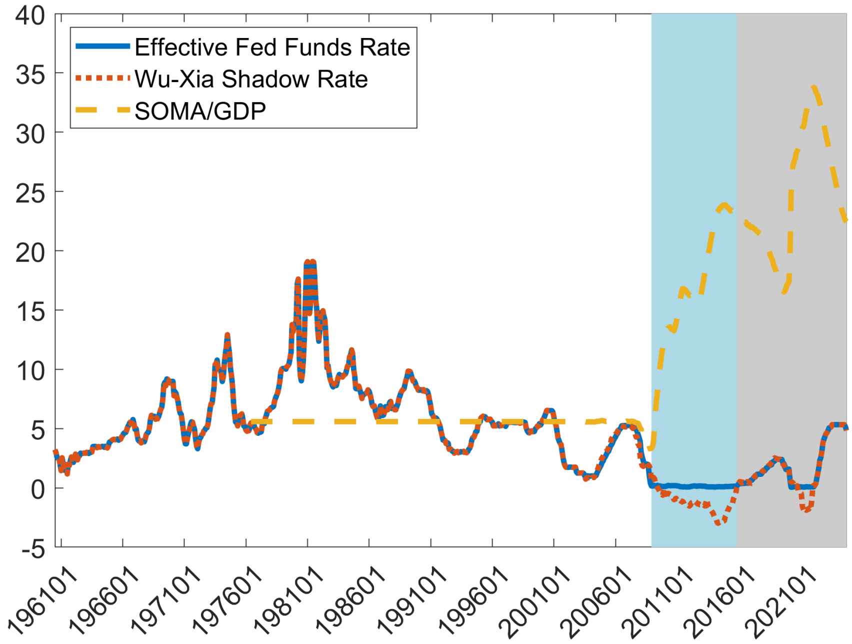
The Great Financial Crisis (GFC) brought new challenges to this paradigm. To shore up activity, many central banks cut policy rates to effective lower bounds (ELBs) and deployed wide-ranging unconventional measures, including forward guidance, liquidity provision, and large-scale asset purchases. Extraordinary at the time, these measures make the policy rate inadequate as a gauge of monetary policy setting. New concepts such as the *shadow rate* helps fill this gap, by extrapolating what the policy rate would have been were the ELB not a binding constraint (Figure 1, blue shade). For example, Wu and Xia (2016) uses a non-linear term structure model to infer this shadow interest rate using information from the yield curve, thus indirectly capturing the effects of forward guidance and expansionary central bank balance sheet policies through their impact on longer-term interest rates.

The period of policy rate normalisation in late-2010s and the post-pandemic tightening marked another significant change (Figure 1, gray shade). As the policy rates rose, central bank balance sheets in most jurisdictions remained elevated. As such, both short-term rate and central bank balance sheets have concurrently become active policy tools. The configuration renders the shadow rate concept obsolete. By definition, the shadow rate equals the policy rate when the ELB is non-binding, and no longer factors in central bank balance sheet policies away from the ELB.[1] This creates a challenge for empirical research that relies on a consistent time-series of monetary policy setting. Moreover, an encompassing indicator that summarises what multiple policy instruments imply for the overall monetary policy conditions targeted by policymakers remains lacking.

In this paper, we resolve these issues by introducing a new aggregate monetary policy conditions index (MCI) that integrates both the conventional and unconventional monetary policies. The MCI aims to capture the overall influence of monetary policy on the economy consistently over time across different regimes, including when both conventional or unconventional policies are jointly active. And by summarising the macroeconomic operations of monetary policy instruments, the MCI remains relevant at the ELB and away from the ELB.

[1] Here we adopt the shadow rate definition in the seminal paper Black (1995), which Wu and Xia (2016) builds on. There are other shadow rates with different definitions, such as Lombardi and Zhu (2018) and Doh and Choi (2016). These series do not necessarily track the Fed funds rate outside the ELB.

Figure 1: Unconventional monetary policy and its legacy



Note: The figure plots the time series of the effective federal funds rate (blue line), the US shadow rate estimated in Wu and Xia (2016) (red dashed-dotted line), and the size of the System Open Market Account (SOMA) portfolio scaled by nominal GDP in the US, from January 1961 to October 2024. All series are in %.

Our key simplifying assumption is that the MCI equals a weighted average of the two policy instruments. Specifically, given short-term interest rate m_{1t} and central bank balance sheet size m_{2t} (scaled, e.g. by nominal GDP), the MCI is given by:

$$m_t = bm_{1t} + (1 - b)(-m_{2t})$$

with an unobserved weight $0 < b < 1$ to be estimated. The negative sign in front of m_{2t} results from opposite impacts from higher policy rate and from larger balance sheet size. With the flipped sign for m_{2t}, higher levels of MCI mean tighter monetary policy setting. Given its simplicity, MCI can be re-normalised to aid interpretation. In particular, $\tilde{m}_t = m_{1t} + \frac{(1-b)}{b}(m_{2t} - m_{2,2007})$, where $m_{2,2007}$ is the constant pre-GFC central bank balance sheet size, reduces to the short-term interest rate over the pre-GFC period, aiding comparisons across time. This simple formulation parsimoniously captures the first-order effects of balance sheet and interest rate policies on financial conditions and the economy.

To pin down b and hence MCI, we first construct a VAR system consisting of MCI, financial conditions, output gap and inflation, and then estimate b jointly with other parameters of the VAR. Estimating MCI within a VAR system confers one key advantage.

It enables an assessment of the dynamic interactions between the MCI and other macro-financial variables within a standard empirical framework, where tools such as the impulse response functions and historical decomposition readily apply.[2] Importantly, the same framework captures the dynamic relationships consistently across different periods irrespective of whether the ELB was binding and even when both the policy rate and unconventional monetary policy (UMP) are concurrently active. In this sense, the MCI supersedes the shadow rate as a summary statistics of monetary policy setting.

We employ a Bayesian estimation routine that iteratively samples b and other parameters, mirroring the usual BVAR estimation procedure. Adopting the Bayesian approach allows us to incorporate the literature's previous findings on the relative impact of unconventional monetary policies into the analysis through the use of the prior distribution of b. This is particularly useful given limited time-series sample in our case.

We use the estimated MCI to revisit classic questions about UMP effectiveness and to address recent policy debates. First, we found substantial contributions from UMP in shoring up economic activity in the aftermath of the GFC when ELB was binding. Second, the monetary policy responses to the pandemic recession were more aggressive than usual, helping keep financial conditions easier than otherwise the case. At the same time, the persistent stimulative effects of these policy actions also contributed to higher post-pandemic inflation surge. Third, and relatedly, post-pandemic monetary policy shocks partly account for the significant swings in financial conditions–the sharp tightening from mid-2021 to early-2023 and the subsequent reversal. To the extent that central bank balance sheet policies may have played a part in driving these policy shocks, their implications may not be as boring as "watching paint dry".

The MCI framework is flexible and accommodates a number of extensions. We allow for a time-varying impact of balance sheet policy by employing expanding-sample estimates, and explore alternative balance sheet policy measures as potential alternatives of central banks instruments. One such approach focuses on the duration profile of the portfolio held by the central bank. Another takes into account the evolution of securities supplied by the Treasury to the market. The baseline results are generally robust to these alternative characterisation of the central bank use of its balance sheet as a monetary policy instrument. As an encompassing measure of monetary policy, the MCI may also prove useful in other empirical applications. For instance, we show that using the MCI significantly mitigates the weak-instrument problem often encountered in high-

[2] This step mirrors previous VAR-based studies that consider the short-term interest rate and central bank balance sheet policies as two separate variables. Such a detailed approach is subject to shortcomings, however. Binding ELB and structural breaks in the balance sheet policy (apparent in Figure 1) violate the Gaussian and linearity assumptions, rendering inferences problematic. Confining the analysis to the post-GFC regime with large balance sheet, as in Gambacorta et al. (2014) and Boeckx et al. (2017), partly mitigates these problems but does not address occasionally binding ELB and switches between active and passive balance sheet policies during this period.

frequency identification of monetary policy shocks. The framework can also incorporate shifts in neutral interest rate and central bank balance sheet size–particularly relevant under ample reserves system where reserve demand has likely increased. By introducing "balance sheet gaps" alongside a more traditional interest rate gap, we obtain a unified measure of monetary policy *stance*. We finally illustrate wider applicability of the MCI framework by estimating a global version of the model and show that the collective use of central bank balance sheet policies also shape monetary policy conditions at the global level.

Literature

We contribute to two main strands of the literature. The first is on the assessment of the qualitative and quantitative effects of balance sheet policies. Our MCI methodology focuses on the *stock effect* of central bank balance sheet policies, highlighted in the literature as more prominent than the flow effect. The stock effect refers to the persistent cumulative impact of the central bank balance sheet size on asset prices, driven by changing expectations about the size and duration of assets available to the public.[3] The flow effect refers to the immediate impact on asset prices at the time of asset purchases or sales, driven by shifts in market liquidity and functioning. Various empirical approaches point to the stock effect as the dominant one. Event-study analyses such as Gagnon et al. (2011) and Krishnamurthy and Vissing-Jorgensen (2011) find significant impacts of policy announcements, consistent with the stock effect. Drawing on security-level data, D'Amico and King (2013) estimate that the Fed's $300 billion purchase of Treasuries in 2009 compressed yields by around 30 basis points persistently over the course of the programme (stock effect), while lowering yields in affected sectors on operation days by only 3.5 basis points (flow effect).[4] Using a term structure model, Li and Wei (2013) find that a 1-percentage-point adjustment in the private holdings of Treasury 10-year-equivalents to GDP ratio would change the 10-year Treasury yield by about 10 basis points. Eren et al. (2023) take a demand system approach and estimate that a 1% increase in central bank holdings of US Treasuries results in a 7-13 basis point drop in long-term yields. As summarised in the Federal Open Market Committee (2016) memo, the important aspect of the effects of balance sheet policy on the macroeconomy is the

[3]The stock effect can arise through a number of mechanisms. One is the portfolio balance channel, where asset purchases/sales remove/add duration risks from/to the market and incentivise investors to rebalance portfolios and readjust risk exposures (Gagnon et al. (2011); Krishnamurthy and Vissing-Jorgensen (2011)). Another mechanism is the signalling channel, where asset purchases reinforce expectations that rates will remain lower for longer Bauer and Rudebusch (2014). This signalling channel might have become weaker in more recent period as central banks chose to adjust the policy rates flexibly to steer the economy and adopted a more passive approach to balance sheet policies, weakening the link between the two tools.

[4]Also leveraging on security-level data, Kandrac and Schlusche (2013) show that flow effects were only present during the early asset purchase programmes, but were of little economic significance.

persistence of these policies' impact on financial prices, i.e. the stock effect. See also Committee on the Global Financial System (2019) which offers a survey of the use of central bank balance sheets as a instrument of macroeconomic stabilisation across the euro area, Japan, the United Kingdom and Japan as well as Bank for International Settlements (2024) for a coverage which also includes recourse to balance sheet policies to stabilize the economy during the Covid lockdowns.

Recent studies suggest central bank balance sheet policies have continued to exert important stock effects on financial conditions after the policy rate has risen from the ELB. Closer in spirit to our paper, some studies have assessed the impact of central bank balance sheet policies in terms of equivalent adjustments in the policy rate. Crawley et al. (2022) employ an augmented version of the FRB/US model to incorporate the effects of central bank asset purchases on term premia, and estimate that the recent balance sheet contraction of 2.5 trillion dollar, or 9% of GDP, is equivalent to 50 basis point increase in the policy interest rate. Wei (2022) utilises a preferred-habitat term structure model and estimates that a reduction in the central bank balance sheet by 2.2 trillion dollar, 8% of GDP, is equivalent to 29-74 basis point of rate hike, based on their expected impact on the 10-year Treasury yield.[5] We contribute to this literature by setting up a summary indicator over a long stretch of period, including the most recent regime when large central bank balance sheets coincide with the policy rate being above the ELB.

Second, we also contribute to the literature on shadow rates. Our MCI is conceptually similar to the shadow rates in their attempt to integrate the short-term interest rate and UMP into a single indicator. That said, there are also important differences. As discussed, the shadow rate of Wu and Xia (2016) is built on the option-pricing definition of Black (1995), and attaches zero weight to the central bank balance sheet policy as soon as the policy rate rises above its ELB. This is problematic if large central bank balance sheets can continue to generate significant stock effects away from ELB, as preceding empirical evidence suggests is the case. Another approach due to Lombardi and Zhu (2018) estimates a dynamic factor model comprising interest rates, money aggregates and central bank balance sheets. It treats the short-term interest rates as missing during the ELB, and extracts the first common factor as the shadow rate. This approach exploits the relationships among monetary policy variables and uses information about yields and monetary quantities to infer what the missing short-term rate should be. One drawback of such factor model approach is that the shadow rate could converge back to the short-term rates once these becoming uncensored above the ELB, thus failing the capture the stock effects of large central bank balance sheets.[6] See also Doh and Choi (2016) for a

[5]Below we also draw on the latter two papers to construct our prior distribution of b when estimating MCI, given the same basis for comparison.

[6]Another possibility is that the first common factor loads more on variables other than the short-term rates, but this would create a wedge between the shadow rate and the policy rate during the pre-GFC period when the influence from central bank balance sheet policies should have been absent.

similar approach using principal component analysis and private-sector borrowing instead of central bank balance sheets as part of the inputs. These shadow rate methodologies thus share a common challenge that could make them non-robust to the regime where both interest rates and central bank balance sheets are active concurrently.

The rest of the paper is organised as follows. Section 2 describes our empirical methodology. Section 3 reports the MCI estimates, the impulse response functions and historical decompositions. Section 4 re-examines the role of monetary policy through the lens of MCI, using a series of counterfactual exercises. Section 5 considers extensions, including a time-varying impact of balance sheet policy, adjustments for portfolio duration and Treasury supply, its application in high-frequency identification of monetary policy shocks, and the incorporation of neutral interest rates and balance sheet size. Section 6 presents a global version of the MCI. Section 7 concludes.

2 Empirical procedure

This section lays out our empirical framework. We first introduce the VAR model with MCI, then describe the data and Bayesian procedure for estimating the MCI weight and other VAR parameters. We then discuss the sign-restrictions used to identify structural shocks.

2.1 Model overview

We assume the dynamic interaction between monetary policy and macro and financial variables can be described in a generic VAR system as follows:

$$X_t = \sum_{\tau=1}^{p} B_\tau X_{t-\tau} + \varepsilon_t \quad \varepsilon_t \sim \mathcal{N}(0, \Sigma), \tag{1}$$

$$X_t = \left[f_t, \pi_t, y_t, m_t \right]', \tag{2}$$

$$m_t = \sum_{\forall i} b_i m_{it}, \qquad \sum_{\forall i} b_i = 1, \tag{3}$$

where f_t, π_t, y_t denote financial condition, inflation, and output respectively. m_t represents the MCI, a indicator that reflects overall monetary policy setting achieved through different policy tools. We assume that MCI can be summarized by a linear combination of individual policy variables m_{it}. Except for the use of MCI in place of the policy rate, this VAR setup is a standard time-series framework for analysing macroeconomic dynamics.

We specify m_t to consist of two policy tools, a short-term interest rate m_{1t} and the size of central bank balance sheet relative to GDP m_{2t}.[7] Guided by information criteria, we restrict attention to the case of two lags ($p = 2$). For convenience, we express the VAR in a one-lag form and write MCI as an average of two observables with one unknown weight b:

$$Z_t = \underbrace{\begin{bmatrix} B_1 & B_2 \\ I & 0 \end{bmatrix}}_{B} Z_{t-1} + \begin{bmatrix} \varepsilon_t \\ 0 \end{bmatrix}, \qquad Z_t = \begin{bmatrix} X_t \\ X_{t-1} \end{bmatrix}. \tag{4}$$

$$m_t = bm_{1t} + (1-b)m_{2t} \tag{5}$$

The objective is then to estimate the parameters $\{b, B, \Sigma\}$.

2.2 Data

Data are monthly and we focus on the United States as a baseline. We use interpolated CBO output gaps as the proxy for y_t. Inflation π_t is the year-on-year CPI inflation, and f_t is the Chicago Fed financial conditions index (NFCI). We consider two measures for monetary policy settings, the 2-year yields and the (negative) size of System Open Market Account (SOMA) as a percentage of nominal *trend* GDP.[8] We choose the 2-year yield to encapsulate the policy interest rate as well as its near-term outlook as shaped by the central bank communication (implicitly and through forward guidance). The balance sheet size captures the stock effects of asset purchases, and is scaled by slow-moving trend GDP for simplicity. Later, we also consider a few alternatives such as controlling for variations in bond supply and considering not only the size but also the duration of the SOMA portfolio. The sample covers July 2003 to October 2024. We de-mean all our series and estimate equation 2 without a constant.

Our choice of NFCI as the financial conditions measure deserves some discussion. As our goal is to capture the endogenous dynamic interactions between financial conditions, macroeconomic developments and monetary policy, an ideal proxy for financial conditions should capture swings in risk appetite and prices of risk that shape the financial conditions, rather than the direct influence of central bank actions themselves. NFCI meets this criterion, as it is constructed from a variety of risk, credit and leverage indicators, with weights that reflect their contributions to the index's overall fluctuations (see Brave and Kelley (2017)). Other financial conditions indices, such as the Goldman Sachs FCI (Hatzius et al. (2017)) or the Federal Reserve's new FCI-G (Ajello et al. (2023)) prominently feature short-term and other risk-free interest rates, and conceptually

[7] We later consider extensions to this stripped-down model and consider alternative measures of monetary policy settings.

[8] SOMA includes the Federal Reserve's holdings of US Treasury securities, agency debt securities, agency MBS and a small amount of foreign securities. It excludes lending facilities, discount window loans and repo/reverse repo operations.

represent an amalgamation of MCI and broader financial conditions. These two indicators also use component weights that reflect their relative impacts on future output, creating a potential endogeneity and circularity problem.

2.3 Estimation

The key estimation challenge is that b is unknown, rendering MCI unobservable and linear regression infeasible. One solution is to estimate b along with other parameters with maximum likelihood estimation (MLE), which, in principles, guarantees asymptotically consistent estimates. In practice, the finite sample size and the relatively limited experience with balance sheet policy poses a key constraint.[9] An alternative strategy is to first pin down b by appealing to an external identification or from prior studies, before proceeding with the VAR estimation. A drawback is a disconnect with the VAR framework and no scope for observed joint dynamics of variables in X_t to inform b.

A Bayesian VAR setup strikes a balance by combining information from both the literature and data within a coherent framework. The first step of the procedure is to construct a prior on the MCI weight b, informed by the existing literature. The joint posterior distribution of $\{b, B, \Sigma\}$ is then estimated using MCMC, employing Gibbs sampling for B and Σ, and Metropolis-Hastings for b. This estimation routine follows a standard Bayesian approach, but requires an additional Metropolis-Hastings step for sampling b.

Given that $b \in [0, 1]$, the prior for b is posited to follow a Beta distribution. The distribution parameters α and β are chosen based on recent studies that have estimated the effects of recent quantitative tightening (QT) in terms of the "equivalent" units of policy rate hikes. Crawley et al. (2022) estimate that the contraction in central bank balance sheet of 2.5 trillion dollar (9% of GDP) is equivalent to 50 basis point increase in the policy interest rate. In our MCI formulation, this implies $b \times 0.5 = (1 - b) \times 9$, i.e. $b = 0.95$. In another study, Wei (2022) finds that the reduction in central bank balance sheet of 2.2 trillion dollar (8% of GDP) has the same effect as a 29-74 basis point hike in the policy interest rate, implying $b \in [0.92, 0.97]$. Based on these estimates, we use $b = 0.95$ as the mean in our prior distribution $(\alpha/(\alpha + \beta))$. In terms of variance, we impose a relatively tight prior given very similar estimates for b from both studies, and set the 'confidence parameter' $\alpha + \beta$ at 200 (implying standard deviation of b at 0.02). As shown below, the posterior nonetheless remains importantly influenced by data.

The estimation procedure iterates over the following steps:

1. (Initialisation) Initialise b at the mean of prior distribution, construct m_t, specify the VAR system, and estimate it with OLS to obtain the initial estimate of B.

[9] To the extent that balance sheet size may be more persistent and easier to fit in a linear model than interest rate, the weight b could even be biased toward zero.

2. Given b and B, compute VAR residuals and draw Σ from its inverse-Wishart sampling distribution based on the sum of squared residuals.

3. Given b and the sampled Σ, draw a new B from its multivariate-Gaussian sampling distribution based on least squares estimates.

4. Given B and Σ, draw b using a Metropolis-Hastings step with a Gaussian proposal distribution and reflecting boundaries to ensure $b \in [0, 1]$. The acceptance probability is based on the log posterior, which combines the Beta prior for b and the VAR likelihood.

5. Iterate steps 2-4 using Gibbs sampling with Metropolis-Hastings used for b.

6. Discard initial burn-in draws, and collect the remaining samples to characterise the joint posterior distribution.

2.4 Shock identification

We next identify shocks of interest using the estimated Bayesian VAR. We focus on four structural shocks: aggregate demand shocks, aggregate supply shocks, risk aversion shocks and monetary policy shocks. These are identified using sign restrictions. We follow Arias et al. (2018) and Uhlig (2017) in imposing minimalistic restrictions and leaving potentially contentious restrictions agnostic. A positive demand shock immediately raises output y_t and prompts monetary policy tightening (higher m_t). A negative supply shock lowers output y_t and raises inflation π_t. A positive risk aversion shock tightens financial conditions (higher f_t) and prompts monetary policy to lean countercyclically by easing (lower m_t). Finally, an unexpected monetary tightening immediately raises m_t and f_t, inducing lower output y_t and inflation π_t with a lag of 6 months. Table 1 summarises these sign restrictions.

Table 1: Sign restrictions scheme

	y_t	π_t	f_t	m_t
Demand shocks	+			+
Supply shocks	−	+		
Risk aversion shocks			+	−
Monetary shocks	− (6m)	− (6m)	+	+

Note: The table shows sign restrictions used to identify (i) expansionary demand shocks, (ii) adverse supply shocks, (iii) risk aversion shocks and (iv) contractionary monetary policy shocks. The effects take place immediately, unless a time lag is specified in brackets (in months). Empty cells imply no restrictions.

This shock identification regime provides a parsimonious description of salient macro-financial dynamics. Demand and supply shocks capture real drivers of growth and inflation over the business cycle. Risk aversion shocks capture exogenous sources of financial stresses and exuberance. Monetary policy shocks cover unexplained variations in policy settings from both the short-term interest rate and central bank balance sheet policies.

3 Estimation results

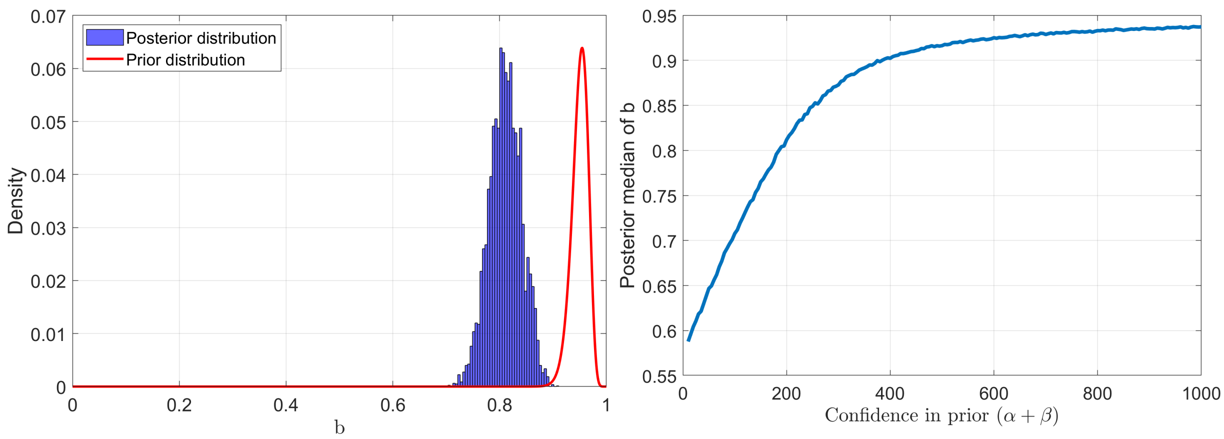
3.1 BVAR estimates

The posterior distribution of b, blue bars in the left panel of Figure 2, lies to the left of the prior distribution. The posterior mean and median of b are approximately 0.81, compared to the prior mean of 0.95. The BVAR estimate thus suggests a greater role of balance sheet policies in the overall monetary policy conditions than in the studies underlying the prior. It suggests that a change in the central bank balance sheet by 10% of GDP is equivalent to 2.5 percentage-point change in the short-term interest rate.

Figure 2: Posterior estimate of b

(a) Posterior estimate and prior of b

(b) Sensitivity of posterior estimate to prior confidence

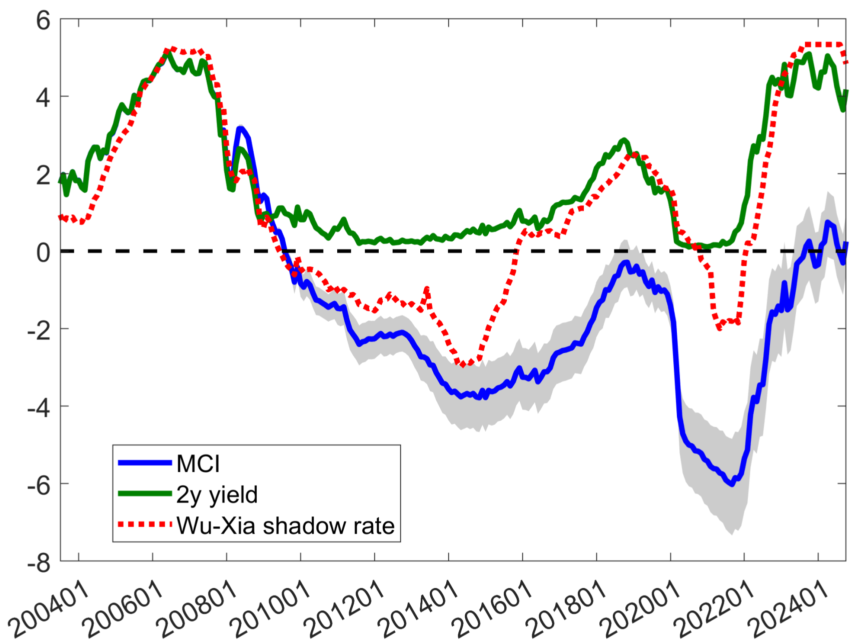


Note: Panel (a) shows the posterior and prior distribution of MCI weight b. Under the prior, b follows a Beta distribution with parameters $\alpha = 190$ and $\beta = 10$. Panel (b) shows the posterior median estimate of b as a function of the confidence in the prior (measured by $\alpha + \beta$), holding fixed the prior mean $\alpha/(\alpha + \beta) = 0.95$. The baseline posterior estimate is based on confidence of $\alpha + \beta = 200$

The posterior median is an increasing concave function of confidence in the prior (inversely related to the prior variance), as shown in the right panel of Figure 2. As prior becomes completely diffuse and confidence approaches zero, the posterior median collapses to the maximum likelihood estimate of $b < 0.6$. The posterior median rises rapidly as one raises prior confidence from a low level, indicating a relatively flat likelihood function. This sensitivity drops noticeably once prior confidence exceeds 200. Our chosen prior confidence at $\alpha + \beta = 200$ strikes an arguably good balance between exploiting previous literature estimates and allowing the data to speak.

The resulting MCI and its distribution are shown in Figure 3, together with the two-year yield and the shadow rate from Wu and Xia (2016). For ease of comparison, we re-normalise the MCI to $m_t/b = m_{1t} + (1 - b)m_{2t}/b$ so that its unit is identical to the two-year yield. The first key observation is that the MCI tracks the shadow rate very closely before and during the period for which the ELB is binding. This provides an external validation to the MCI estimate. At the same time, in the post-ELB period, a notable gap has emerged between the MCI on the one hand, and both two-year yield and the shadow rate on the other. In 2016, as the central bank lifted the policy rate from the ELB, the two-year yield rose meaningfully above zero, and the Wu-Xia shadow rate, by definition, converged to it. While the MCI also rose, its level remains far below that at the start of the ELB period, reflecting the enlarged central bank balance sheet.

Figure 3: Monetary Policy Conditions Index



Note: MCI is based on the median posterior estimate of b, with grey shaded area reflecting the one standard deviation band of b posterior estimate. Shadow rate is based on Wu and Xia (2016).

The economy faced a binding ELB again during the pandemic recession, in response to which the central bank expanded its balance sheet to a new high of over 37% of GDP. Reflecting this exceptional degree of policy accommodation, MCI reached a new low. The shadow rate fell below zero again during this period, but, unlike MCI, the level stayed above the post-GFC trough. After the pandemic, the inflation surge prompted the central bank to raise the policy rate to the highest level in more than 20 years, and the two-year yield as well as the shadow rate jumped to match the pre-GFC peak in 2006. The MCI also tightened substantially over this most recent period, but due to the still large central bank balance sheet, its level only marginally exceeds the pre-pandemic level and remains similar to that in 2009 when the central bank had lowered the policy rate to the ELB and launched large-scale asset purchase programme. The substantial tightening in the short-term interest rate has been offset by the legacy of large balance sheet in the wake of the pandemic, implying materially less tightening in policy setting than suggested by interest rates alone.

3.2 Impulse response functions

We next present the impulse response functions in Figure 4, with shocks organised along the columns and variables along the rows. The risk aversion shocks (first column) cause a tightening in FCI lasting about half a year and a persistent easing in MCI over two years. The tightening financial shocks take about a year to transmit and induce a significant decline in output. The impact on inflation is insignificant throughout. Persistent countercyclical response of monetary policy to financial stresses explain these relatively muted real effects of risk aversion shocks.

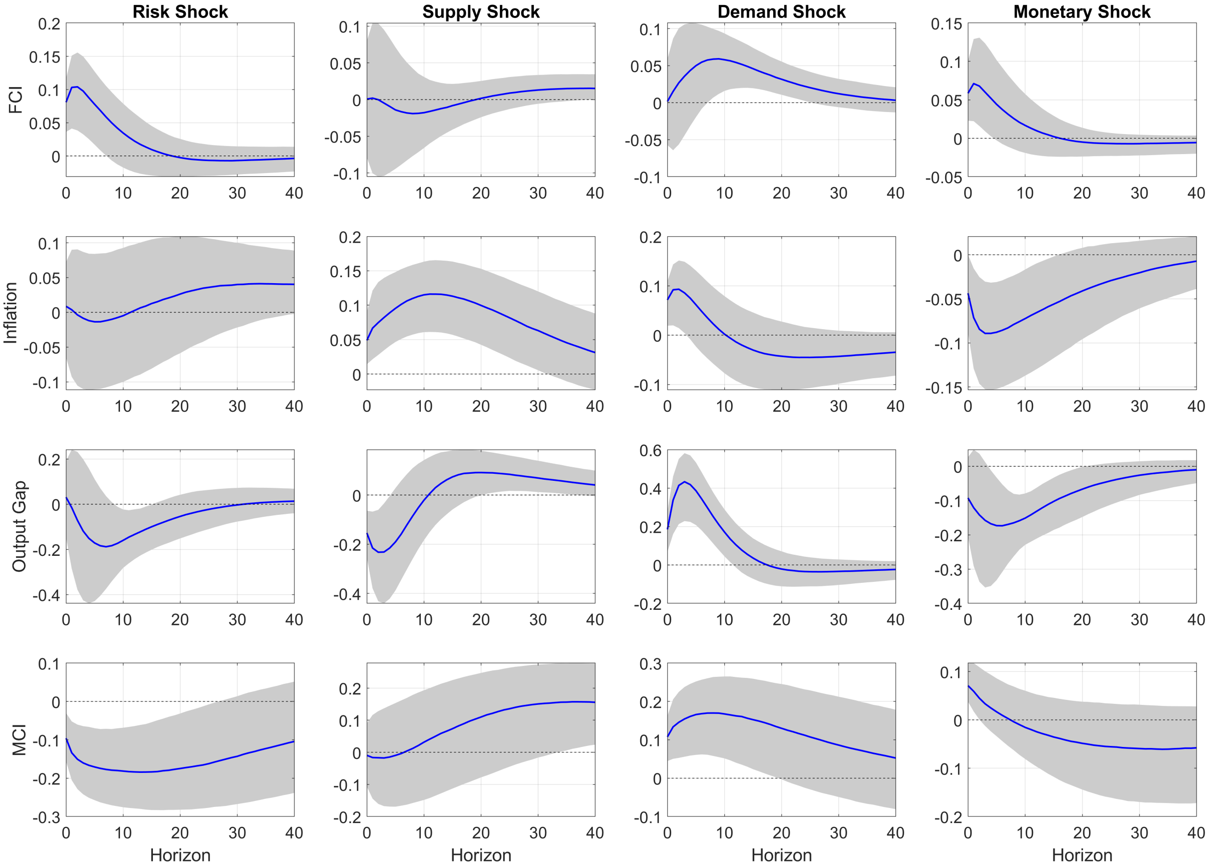
Adverse supply shocks (second column) drive up inflation persistently for over two years, but generate a relatively short-lived negative impact on output. The pattern reflects the data features where output tends to recover fairly quickly from supply shocks while inflation lingers longer, as was the case after the pandemic for example. The responses of MCI to adverse supply shocks are insignificant in the near term, but turn more restrictive in the medium-term. This delayed response is driven by both the policy reaction to persistent inflation and the indirect effect of higher inflation, which eases 'real' monetary conditions and boosts medium-term output.

Positive demand shocks (third column) raise output and tighten monetary conditions persistently for one year and 20 months, respectively. The increased demand pressure translates into an immediate positive impact on inflation. Higher output and tighter MCI have opposite effects on FCI, leaving insignificant net effects in the near term.[10] But after a year, the effect from higher MCI dominates, leading to tighter financial conditions.

Finally, the impulse responses of monetary policy shocks are sensible in line with intuition. The impact on FCI lasts about half a year, before tapering off. The impacts on inflation and output are more persistent, lasting over a year in both cases. Meanwhile, the effect of MCI shock on itself is very short-lived and subsequently reversed (though statistically insignificant). Note that the sign restrictions appear to have successfully

[10]Higher output generally supports easier financial conditions by increasing assets' expected cash flows and lowering risk premium. Tighter monetary conditions raise the risk-free discount rate, putting a pressure on financial conditions.

Figure 4: Impulse response functions



Note: The figure shows the impulse response functions, with sources of shocks in columns and endogenous variables in rows. Horizons on the x-axis are in months. Blue lines are median impulse responses across all accepted draws of Bayesian estimates. Gray shades represent the one standard deviation band.

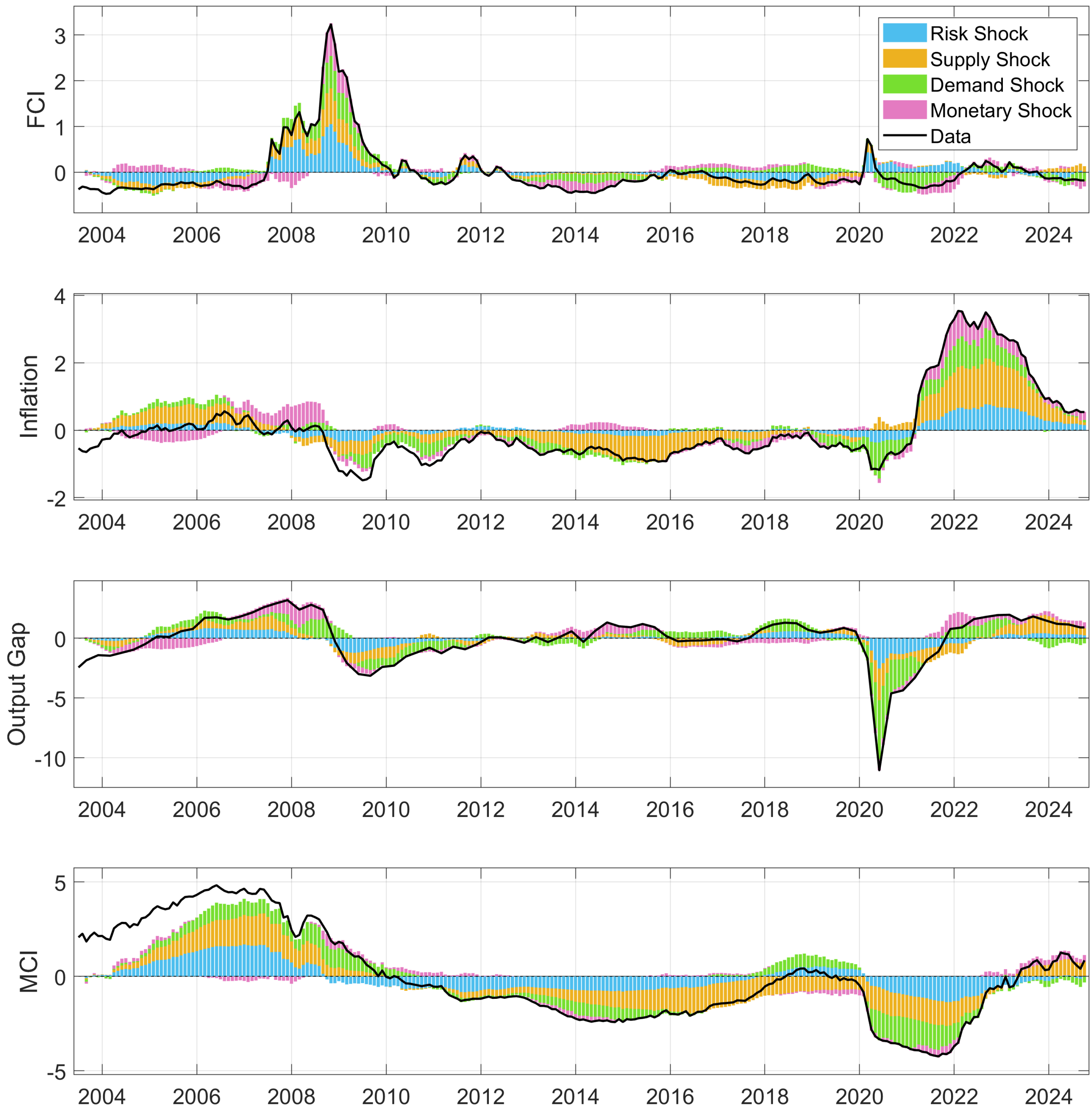
differentiated monetary policy shocks from financial risk appetite shocks, despite both having similar impacts on FCI and output. It is the response of MCI that critically distinguish the two.

3.3 Historical decomposition

We next conduct a historical decomposition exercise to shed light on the proximate drivers of output, inflation, financial conditions, and monetary policy conditions during key historical episodes. The results are shown in Figure 5 (and Figure A.1 for the post-pandemic period).

During GFC, FCI spiked sharply, induced most importantly by risk aversion shocks, followed by negative demand and supply shocks. The large falls in inflation and output during 2009-2010 can be similarly attributed to financial risk aversion shocks as well as

Figure 5: Historical decomposition



Note: The figure shows the historical decomposition of endogenous variables, differentiating contributions from four structural shocks as coloured bars. Each bar is the mean of historical decompositions across all accepted draws of Bayesian estimates.

real demand and supply shocks. Monetary policy shocks provided a lift to the economy leading up to the crisis, keeping FCI easier and output/inflation higher than otherwise would have been the case. But at the height of the crisis in late-2008 to early-2009, even the aggressive monetary policy measures did not keep pace with the deteriorating situation and MCI shocks contributed positively to the FCI spike.

Turning to the more recent episode of pandemic recession in 2020, the sharp fall in output can be attributed primarily to adverse demand shocks, with risk aversion and supply shocks playing secondary roles. The historic surge in inflation that soon followed during 2021-2023 was driven mainly by adverse supply shocks, but with demand and risk appetite shocks also contributing meaningfully. Notably, monetary policy shocks contributed to the inflation increase as well, and at its peak added as much as 1 percentage point to headline inflation in 2022. All these shocks eventually waned and led to the decline in inflation, though the influence from supply shocks was the slowest to dissipate.[11]

The historical decomposition of MCI reveals varying influence of shocks on the central bank policy decisions. Risk appetite and demand shocks are most important drivers of cyclical variations in monetary policy setting, particularly around sharp turning points such as the GFC and the pandemic recession. Meanwhile, supply shocks appear to be more relevant in accounting for the secular trend of MCI. During the post-GFC low-for-long decade, positive supply shocks appear to have driven a decline in MCI. One interpretation is that supply tailwinds have allowed monetary policy to play a more active role in supporting output without fueling inflation. This supply shock contribution has, however, reversed since the pandemic.

The decomposition of FCI helps explain the reaction of financial markets to macroeconomic developments. Some of this may appear puzzling, for example the easing of FCI since 2023 despite a steady tightening in the MCI and the largest increase of short-term rate in two decades. Figure 5 and A.1 show how the negative demand and MCI shocks have been mainly responsible for this easing, more than offsetting the effects of supply shocks. In the next section, we dissect the recent drivers of FCI more precisely to show the relative importance of these different factors.

4 Counterfactual analyses

In this section, we zero in on specific episodes and study the roles of monetary policy, through the new measure MCI, affect the economy. We do so through several counterfactual scenarios.

[11] See also Wu et al. (2024) for a different approach which finds limited role.

4.1 The effects of post-GFC asset purchases

How much did large-scale asset purchases introduced in response to the GFC contribute to shoring up economic activity? We address this question within our framework in the following way. We first note that, during the ELB period from December 2008 to November 2015, the additional easing in monetary policy came entirely from asset purchases. We then construct a counterfactual scenario where the central bank had not embarked on asset purchases and kept its balance sheet at the pre-GFC average level, $\bar{m}_2$. The counterfactual path of MCI of:

$$m_t^{counter} = b_t m_{1t} + (1 - b)\bar{m}_2 \tag{6}$$

implies a difference to MCI of:

$$\Delta_t^m \equiv m_t^{counter} - m_t \tag{7}$$

$$= (1 - b)(\bar{m}_2 - m_{2t}) \tag{8}$$

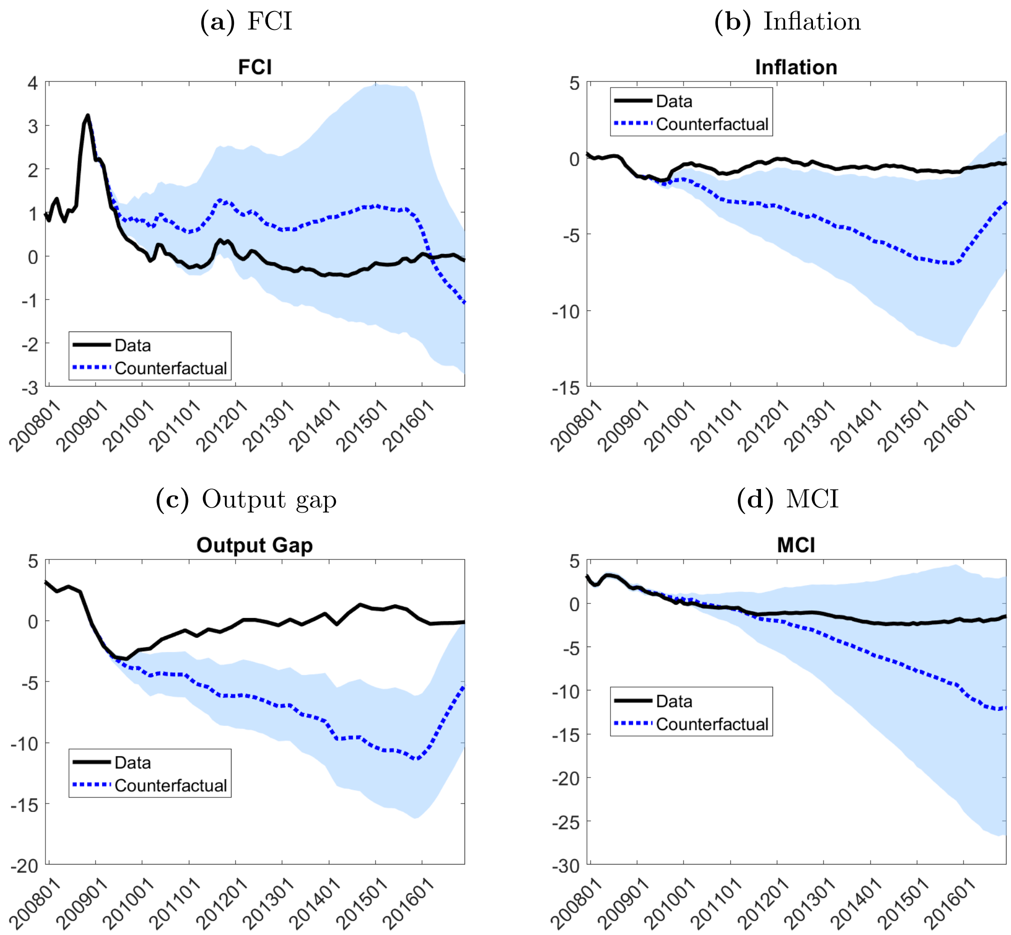
where t is between December 2008 - November 2015. We evaluate the accommodative effects of the entire programme of asset purchases during this ELB period, by implementing Δ_t^m as a sequence of MCI shocks to the BVAR system. That is, the counterfactual scenario assumes sustained policy surprises due to no active UMP.

The results, shown in Figure 6, point to substantial accommodative effects of UMP. Absent asset purchases, financial conditions would have remained as tight as the stressed level in early 2008. Output gap and inflation would have declined steadily throughout the ELB period, and at their troughs, would have been more than 10 and 5 percentage points below their respective averages. Due to the systematic monetary policy response, MCI would have declined substantially, but would have remained too tight to revive the economy given the assumed MCI shocks. Note that, since this counterfactual exercise is based on a single-regime VAR, it does not capture the indirect effects that a prolonged recession could have on inflation expectations, which could have implied even more severe inflation and output outcomes.

4.2 The effects of pandemic responses

Another question relevant to recent policy discussion is whether and how much monetary policy contributed to the post-pandemic inflation surge. We tackle this question by considering the counterfactual scenario where monetary policy setting had been perfectly in line with the historical reaction function and did not respond any differently to the pandemic recession. This exercise asks whether an extraordinarily accommodative monetary policy setting, designed to curb the downside risks to the economy, may have

Figure 6: Counterfactual: No forceful GFC response



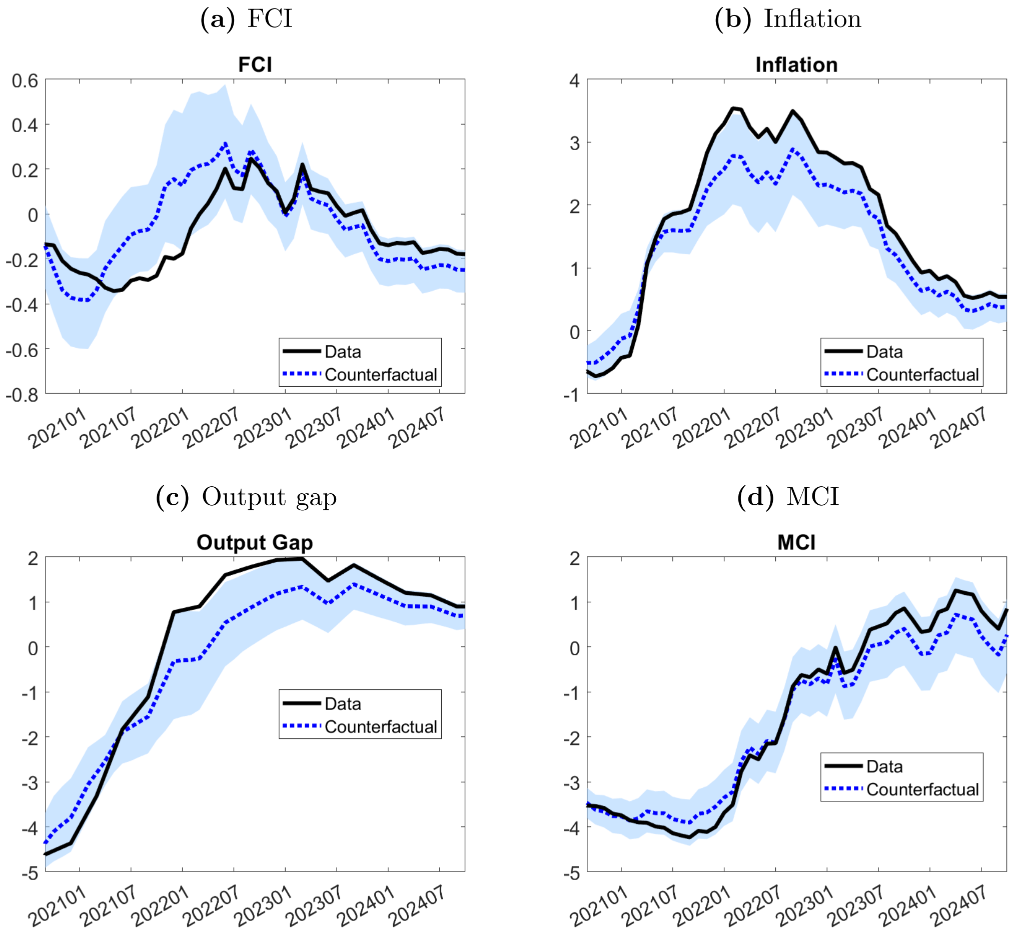
(a) FCI **(b)** Inflation

(c) Output gap **(d)** MCI

Note: The figure shows model simulation, with median counterfactual paths shown in dashed blue lines and data shown in black lines. Counterfactual paths assume positive MCI shocks during the first ELB period of December 2008 to November 2015. The shocks are the differences between observed balance sheet size and its pre-ELB level. Shaded areas represent the one standard deviation band.

contributed to the subsequent rise in inflation. We construct this counterfactual scenario by assuming zero MCI shocks between March 2020 and February 2022, a period for which the pandemic recession kept monetary policy at the ELB.

Figure 7: Counterfactual: No forceful pandemic response



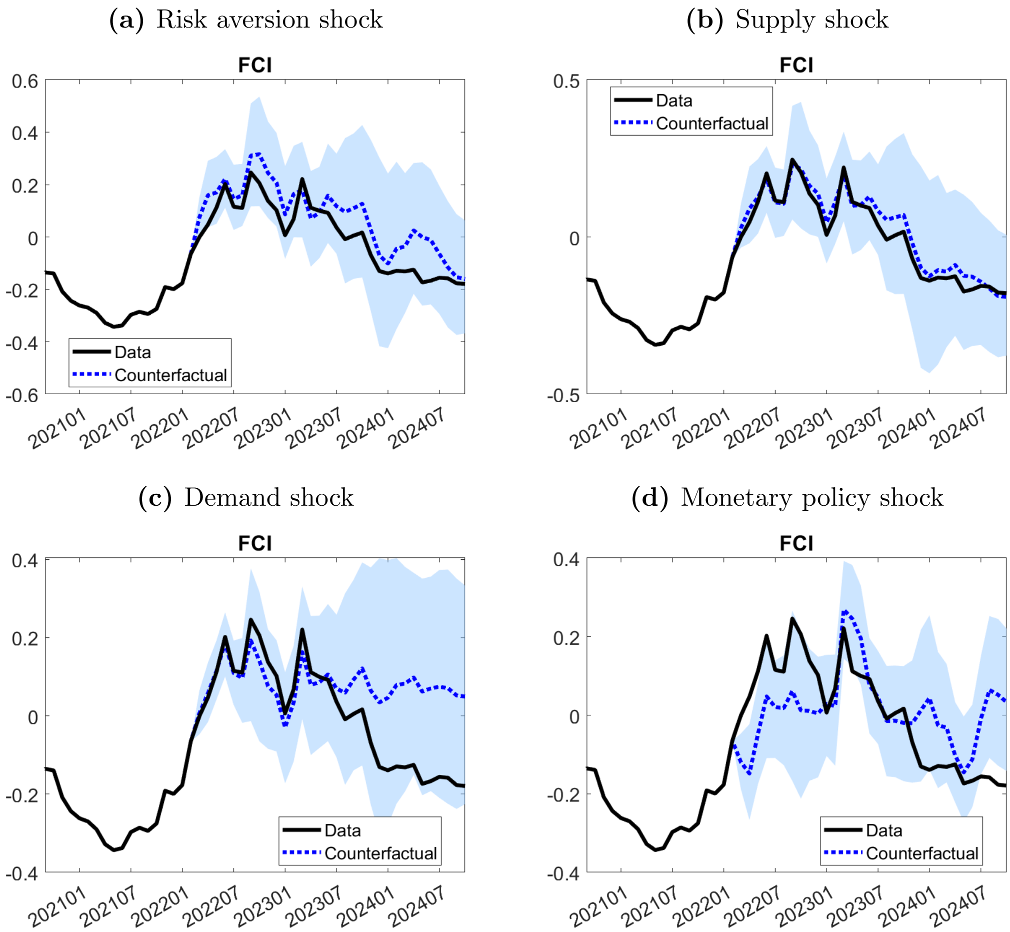
Note: The figure shows model simulation, with median counterfactual paths shown in dashed blue lines and data shown in black lines. Counterfactual paths assume zero MCI shocks during the ELB period of March 2020 to February 2022. Shaded areas represent the one standard deviation band.

The counterfactual simulation, shown in Figure 7, provides one perspective into the consequences of pandemic-era monetary policy response. MCI during the ELB period was indeed more accommodative than average policy reaction conditional on output and inflation developments. As intended, these MCI shocks have kept financial conditions easier and output higher than otherwise would have been the case. Extraordinary monetary policy actions relative to the rule helped close output gap about half a year earlier and sustained it at a level that is one percentage point higher for over a year. At the same time, these easing MCI shocks have contributed to higher inflation, by one percentage point at its peak. The exercise thus points to both the benefits and negative consequences of monetary policy actions.

4.3 Explaining the disconnect of FCI and monetary policy

The final counterfactual exercise examines the drivers of post-pandemic evolution in FCI, and accounts for the easing since mid-2020 in an apparent disconnect with monetary policy tightening. We consider four counterfactual scenarios, each assuming the absence of one structural shock at a time, after March 2022.

Figure 8: Contributions to post-pandemic FCI dynamics



Note: The figure shows model simulation of FCI, with median counterfactual paths shown in dashed blue lines and data shown in black lines. In each panel, the counterfactual path assumes the absence of one structural shock after March 2022. Shaded areas represent the one standard deviation band.

As Figure 8 shows, demand and monetary policy shocks were the most important drivers of recent FCI decline. In the absence of negative demand shocks, the FCI would have remained stable at a level similar to its average in 2022. Without monetary policy shocks, the FCI would have been more stable too. It would not have tightened as much in 2022 in the first place and would have stayed closer to the historical average level of zero throughout the period.

5 Extensions and robustness

5.1 Time-varying impact of balance sheet policy

Our baseline specification assumes a constant weight b in the formulation of MCI, so that the substitutability between interest rate and balance sheet policies remains the same throughout. However, the impact of the balance sheet policy could change over time. For example, a cross-country analysis of Du et al. (2024) suggests that the effects of QT to date, while more significant than "paint drying", have been less powerful than those of quantitative easing (QE). Eren et al. (2023) find that the impact of QE and QT depends on the composition of Treasury investors. At the same time, the effects of QT could increase nonlinearly once shrinking reserve supply hits the steeper part of the reserve demand curve. Post-GFC regulatory reforms and changes to monetary policy operation framework may have shifted reserve demand curve and raised this 'neutral' central balance sheet size–see Afonso et al. (2022) and Lopez-Salido and Vissing-Jorgensen (2021).[12]

To explore potential time variations in the impact of balance sheet policy vis-à-vis that of interest rate policy, we estimate our model over expanding samples. The initial sample consists of 10 years of data and progressively includes more data points as time moves forward. To keep the relative influence of prior versus likelihood constant throughout the expanding sample, we adjust the prior confidence parameter in proportion to the sample size in each iteration.[13]

As shown in Figure 9 (left panel), the estimated b time-series from the expanding sample analysis exhibits non-negligible variations. At first, the point estimates were relatively stable, hovering at around 0.85 between 2014-2018. The reduction in central bank balance sheet size from late 2018 to 2019 then coincided with a fall in b to 0.8, suggesting a stronger relevance of balance sheet policy. After the pandemic outbreak, the estimated weight jumped to around 0.9, indicating a weakened impact of balance sheet policy. The latest round of QT since 2022 again saw the b estimate gradually declining. This pattern of balance sheet policy gaining influence during the QT phases appears, at face value, consistent with the nonlinear effects associated with the steeper region of reserve demand curve. That said, in quantitative terms, the estimated weights b from the

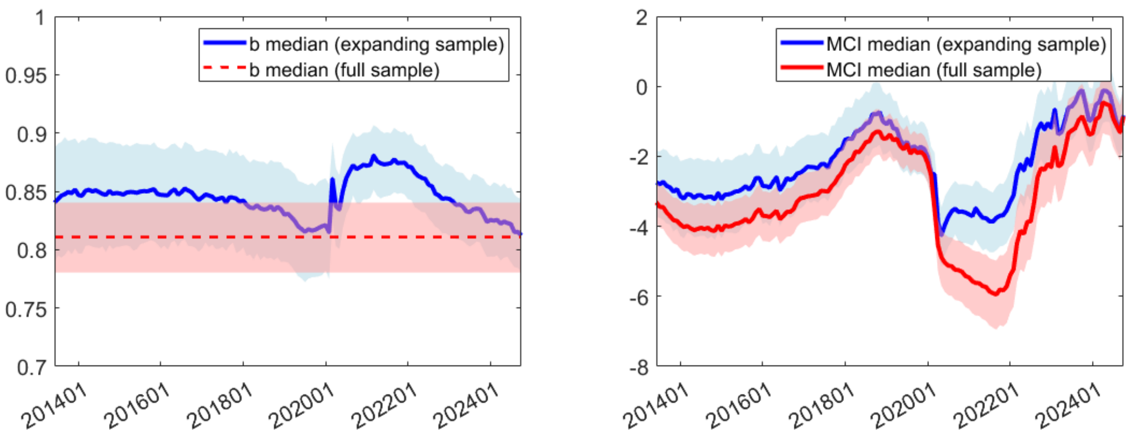
[12] In the words of Du et al. (2024), "...frictions could increase in the future so that QT quickly evolve into watching "water boil"".

[13] A fixed confidence parameter would imply diminishing influence of the prior on posterior as the sample expands. This would produce an artificial drift of estimated b from a value closest to the prior at the initial sample to the full-sample posterior estimate, even when the likelihood estimate is constant. We adjust the confidence parameter to remove this artificial effect.

expanding and the full samples are not significantly different, suggesting a largely stable impact of balance sheet policy. Indeed, as shown in the right panel, the MCIs from full and expanding samples are highly correlated and track each other closely.

Figure 9: Time-varying MCI

(a) b estimated from expanding samples **(b)** MCI estimated from expanding samples



Note: Panel (a) compares b estimated from expanding samples (blue line for median estimate and light blue shaded area for 16%-84% percentile confidence band) and estimated from the full sample (red dash line for median estimate and light red shaded area for 16%-84% percentile confidence band). Panel (b) compares MCI implied by corresponding b estimates

5.2 Alternative balance sheet policy measures

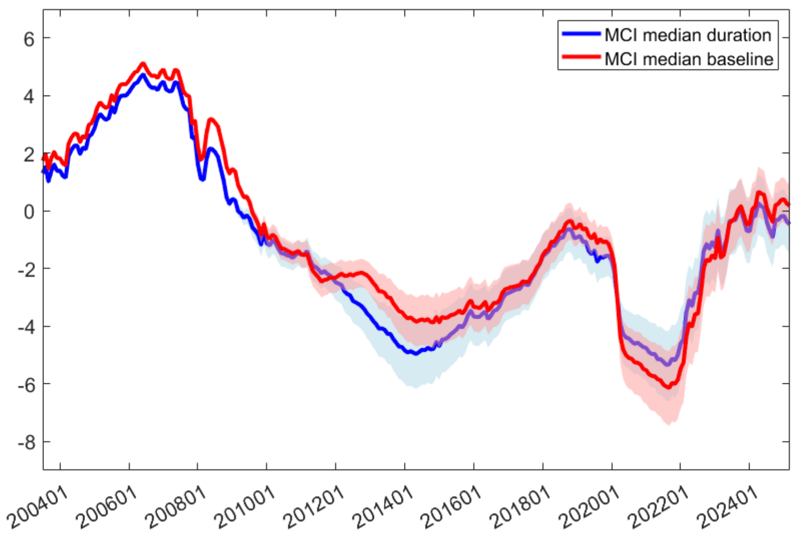
Our analysis so far focus on the size of the SOMA portfolio and abstract from two potentially relevant factors: the portfolio's duration and the supply of Treasuries. Under the portfolio balance channel, central bank asset purchases work by absorbing duration risks from the market, raising bond prices and pushing investors to invest in other risky assets. Through this mechanism, it is not only the par value of the SOMA portfolio but also its duration that determines the extent to which central bank purchases remove duration risk from the market. Additionally, shifts in the overall supply of government bonds can also produce similar effects to those of central bank balance sheet policies, suggesting a potential link between the effectiveness of central bank balance sheet policies and fiscal policy/debt management.

To account for the duration of the SOMA portfolio, we construct a proxy for the ten-year equivalents of the SOMA portfolio.[14] We then replace SOMA as a percentage of nominal trend GDP by the ten-year equivalents of the SOMA portfolio-to-GDP ratio.

[14] We calculate the ten-year equivalents of a fixed-income portfolio as (par value of the portfolio × average portfolio duration)/(duration of the ten-year on-the-run Treasury note). We approximate duration by maturity and use the average maturity of SOMA's Treasury holdings as a proxy for the maturity of the entire portfolio.

Figure 10 plots the MCI under the alternative balance sheet policy measure together with the baseline MCI. The MCI with duration adjustment declined during late 2011 and 2012 while the baseline MCI were more or less flat. This reflects the Federal Reserves operational twist program where the central bank sell short-term Treasury securities and purchase an equivalent amount of long-term Treasury securities. While this program did not enlarge the SOMA portfolio, it lengthened the duration of the portfolio. More recently, the MCI with duration adjustment suggests a slower normalization compared to the baseline MCI. This is because the average maturity of the Federal Reserves' Treasury holdings has been gradually increasing since 2020. That said, the two MCIs' confidence bands largely overlap with each other, indicating robustness of our baseline MCI.

Figure 10: MCI with duration adjustment

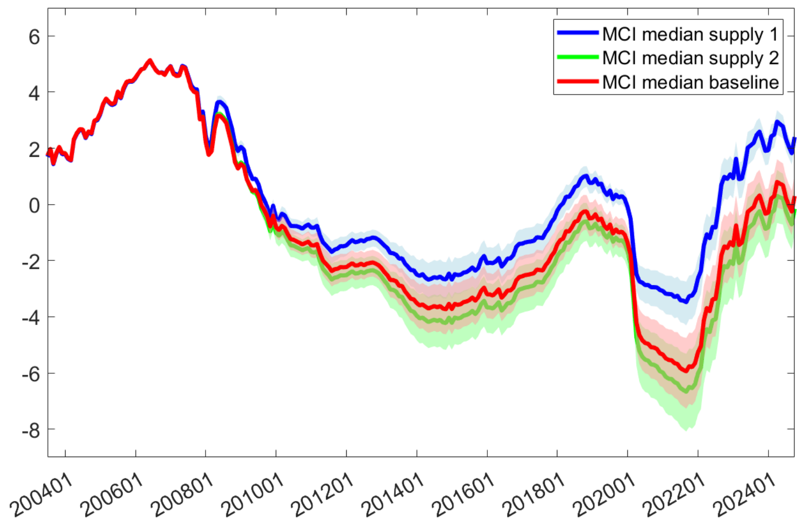


Note: Blue line is the median MCI when we replace the size of SOMA as a percentage of potential GDP with a proxy for the SOMA ten-year equivalents to potential GDP ratio. Red line is the median MCI in our baseline model for comparison. The shaded areas indicate respective 16%-84% confidence intervals.)

We conduct two exercises to account for the influence of the supply of government bonds. The first exercise replaces the size of SOMA as a percentage of nominal trend GDP by the size of SOMA as a percentage of total outstanding government debt and agency mortgage-backed securities (MBS). The idea is that what matters for asset prices is the supply of government bonds available to investors, namely total outstanding bonds net of central bank holdings. Similar measures have been used in the literature, such as in Li and Wei (2013), to examine the impact of QE. However, this approach may not fully capture the signalling channel of balance sheet policy, a potentially important mechanism. In addition, as this measure is influenced by both monetary and fiscal policies, the resulting MCI no longer has the intuitively appealing interpretation of being a proxy for monetary policy actions. As such, we also implement a second exercise that simply adds total outstanding government debt and agency MBS, also expressed as a percentage of nominal trend GDP, as an exogenous variable to the original VAR.

Figure 11 compares MCIs under the two approaches discussed above. Estimates from the first approach closely track the baseline results. The two series differ somewhat during the pandemic outbreak. The MCI that uses the size of SOMA as a percentage of total outstanding debt shows a smaller decline as the outstanding debt surged after the Covid, partly offsetting the massive SOMA purchase. That said, estimates from the second approach almost overlaps with the baseline results. On balance, these results suggest that our baseline MCI is quite robust to controlling for bond supply considerations.

Figure 11: MCI with supply factors



Note: Blue line is the median MCI when we replace the size of SOMA as a percentage of potential GDP with the size of SOMA as a percentage of total outstanding government debt and agency MBS. Green line is the median MCI when we add the size of total outstanding government debt and agency MBS as an additional variable in the VAR. Red line is the median MCI in our baseline model for comparison. The shaded areas indicate respective 16%-84% confidence intervals.)

5.3 High-frequency monetary policy shocks

We next explore the MCI's properties in an empirical application that has received increasing attention–the identification of monetary policy shocks using high-frequency data as instruments. Such identification strategy exploits asset price changes within a narrow window around policy announcements to identify exogenous shifts in monetary policy. One challenge with such approach is that high-frequency shocks are often found to be weak instruments for innovations in the short-term interest rates. A potential explanation is that these high-frequency shocks reflect influences from changes in both the policy rate and balance sheet policies, while short-term interest rates primarily capture only the former. If so, a more encompassing monetary policy indicator such as MCI may offer a solution.

We show in Appendix B that using the MCI as the monetary policy indicator indeed alleviates the problem of weak instrument. We consider three sources of high-frequency monetary policy shocks (Bu et al. (2021), Swanson (2021) and Kearns et al. (2023)). Following Gertler and Karadi (2015), we test how these shocks fare as external instruments for the VAR residuals under alternative monetary policy indicators, pitching MCI against one-year yields, two-year yields, and the central bank balance sheet size. We find that the three shock series become uniformly stronger instruments when MCI is used as a policy indicator, often by a significant margin.

5.4 Neutral interest rate and balance sheet

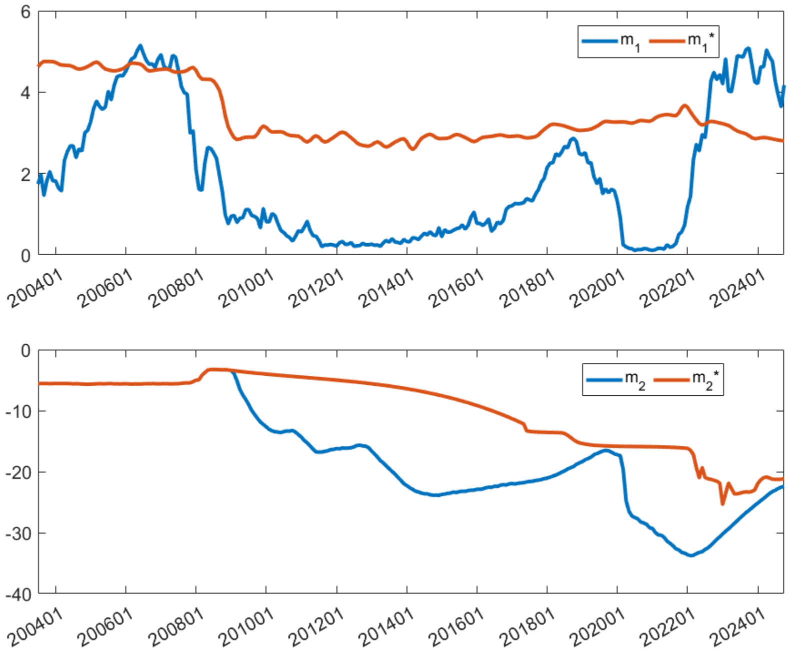
Our baseline VAR model follows the convention of including monetary policy variables in level terms, and is silent on questions related to monetary policy *stance*, i.e. how tight or loose monetary conditions are relative to their *neutral* benchmarks. Under this "gap" perspective, a lower short-term interest rate need not imply more accommodative policy if the natural rate of interest, or r-star, falls over the same period (see Benigno et al. (2024) for a review of shifting r-star narratives and underlying rationales). Similarly, an expansion in the central bank balance sheet need not loosen policy stance if it coincides with a higher neutral balance sheet size, or "B-star". Whether B-star has increased and why remains subject to active debate. One prominent hypothesis is that the demand for central bank reserves may have grown, as banks and other financial institutions require higher liquidity to meet more stringent regulations post-GFC, as well as to self-insure against liquidity risks amidst thin interbank market activity under the "ample reserve" regime (see Logan (2023) and Lopez-Salido and Vissing-Jorgensen (2021)). A complementary hypothesis is that the ample reserve system raises reserve demand by effectively eliminating the opportunity cost of holding reserves (see Borio et al. (2024) for a discussion of this argument).

To incorporate potentially moving r-star and B-star, we re-specify MCI as a linear combination of policy *gaps* instead of levels. For the policy interest rate gap, we replace m_{1t} by $(m_{1t} - m_{1t}^*)$, where m_{1t}^* is the neutral nominal short-term interest rate, proxied by the Holston et al. (2017) r-star estimate plus 2% inflation target as in the literature. The balance sheet policy gap is a more novel concept, which, in the absence of a well-established empirical measure, we measure it using surveys. We specifically draw on the Survey of Primary Dealers and Survey of Market Participants conducted by the New York Federal Reserve bank, and collect the expected steady-state levels of central bank balance sheet at each survey date. We compute B-star or m_{2t}^* by dividing the steady-state nominal balance sheet size by the trend GDP level as of the date at which balance sheet size reaches its steady state.[15] Figure 12 plots the time-series of m_1 and m_2 together with

[15]The New York Fed surveys provide the expected steady-state SOMA size as well as the date at which

their respective equilibrium/steady-state levels.

Figure 12: Monetary variables and their equilibrium levels



Note: Blue lines are the monetary variables, consisting of 2-year yields and -SOMA/GDP. Red lines are respective equilibrium/steady-state levels. The equilibrium level for m_1 relies on estimates from Holston et al. (2017) and the steady-state level for m_2 is constructed based on New York Federal Reserve Bank Primary Dealers and Market Participants Surveys.

We consider two alternative approaches to incorporating balance sheet gaps into MCI. The first introduces the balance sheet gap in the same way as the interest rate gap:

$$m_t^a = b(m_{1t} - m_{1t}^*) + (1 - b)(m_{2t} - m_{2t}^*) \tag{9}$$

This approach extends the baseline MCI by simply replacing the levels m_{1t} and m_{2t} by their gap counterparts $(m_{1t} - m_{1t}^*)$ and $(m_{2t} - m_{2t}^*)$. One advantage of this approach is its simplicity, and the fact that the estimation procedure and interpretation are straightforward and virtually identical to before. A key assumption is that the steady-state balance sheet size m_{2t}^* reported by survey participants must coincide with the macroeconomic notion of neutral balance sheet policy, i.e. one that neither stimulates nor slows economic activity.

The second approach captures the role of m_{2t}^* more precisely by delineating the channels through which the central bank balance sheet policy affects the economy. As

SOMA ceases to change in size, allowing this calculation. Pre-2025 surveys include separate responses of primary dealers and market participants, and we take an average of the two. Questions on B-star are available from May 2017 but not consistently in all surveys. Prior to the GFC when the scarce reserve system prevailed, we assume B-star equals actual SOMA size. We interpolate the missing data points to obtain a complete monthly series for m_2^*.

noted, m^*_{2t} may have increased on account of a higher demand for central bank reserves needed for financial institutions to operate smoothly. Once m_{2t} approaches m^*_{2t} and reserves become scarce, banks may have insufficient liquidity for settlement and regulatory purposes, possibly resulting in higher short-term interest rates which lead to tighter financial conditions. These *liquidity effects* operate through reserves on the liability side of central bank balance sheet, and are distinct from the stock effects arising from large-scale asset purchases which operate through the asset side. The distinction is important because the two channels operate independently. Moreover, the liquidity channel could in principle produce nonlinear effects on MCI. Banks function normally unaffected by m_{2t} shifts as long as m_{2t} is sufficiently large relative to m^*_{2t}, but may need to respond strongly to the liquidity squeeze once m_{2t} gets close to m^*_{2t}. By contrast, because the stock effects should vary with the amount of central bank asset holdings (subject to duration and bond supply profiles), linearity is arguably a good approximation.

To capture separate influences from the liquidity and the stock effects of balance sheet policy, we include two balance sheet gaps in the MCI:

$$m^b_t = b_1(m_{1t} - m^*_{1t}) + b_2 \underbrace{(m_{2t} - m_{2,2007})}_{\substack{\text{Stock effects} \\ \text{(asset side)}}} + b_3 \underbrace{\max[0, ((1-\varepsilon)m_{2t} - m^*_{2t}]^2}_{\substack{\text{Liquidity effects} \\ \text{(liability side)}}} \tag{10}$$

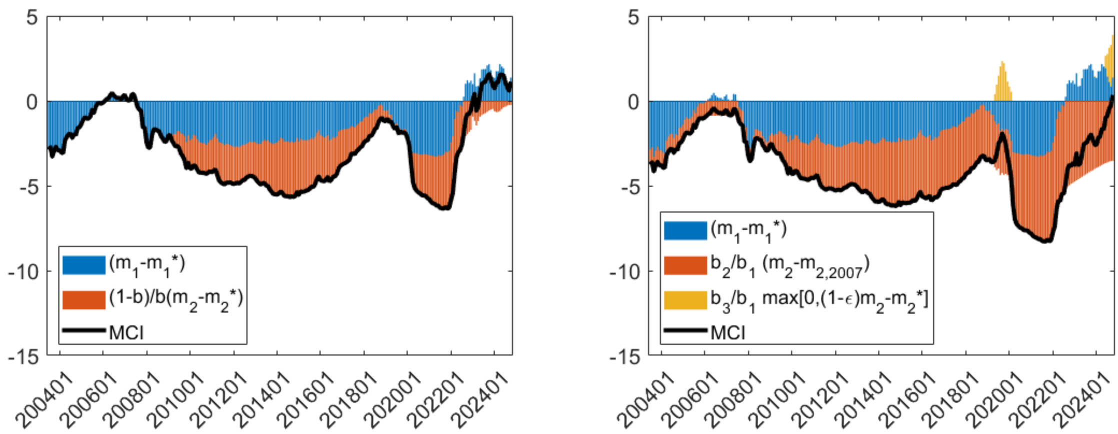
where $0 \leq b_1, b_2, b_3 \leq 1$, $b_1 + b_2 + b_3 = 1$ and $\varepsilon > 0$. Note that the first balance sheet gap uses the pre-GFC balance sheet size relative to GDP, $m_{2,2007}$, as the neutral benchmark, assuming constant B-star for the stock effects (consistent with the baseline MCI above). The second balance sheet gap corresponds to the liquidity effects and embeds two nonlinearities. The max operator ensures that the liquidity effects are negligible once m_{2t} is sufficiently large relative to the neutral benchmark m^*_{2t} (with tolerance parameter ε). The gap is squared so that, as m_{2t} approaches and undershoots the threshold, the tightening effect of balance sheet policy grows nonlinearly. We calibrate ε to 0.1 to construct the liquidity term, and estimate the new MCI weights using the Bayesian method as above, except specifying the priors of $\{b_1, b_2, b_3\}$ as following a Dirichlet distribution, a multivariate generalisation of the beta distribution. We set the prior means at $0.95, 0.04, 0.01$, with the same standard deviation as before.

Figure 13 presents the estimation results from both approaches. Panel (a) shows the estimated (re-scaled) MCI, $\tilde{m}^a_t = (m_1 - m^*_1) + \frac{(1-b)}{b}(m_2 - m^*_2)$, and its two components in stacked bars. Prior to the 2022 hiking cycle, the interest rate and balance sheet gaps were both generally negative, contributing to persistent MCI accommodation. The subsequent hiking cycle saw the interest rate gap turning to positive. The balance sheet gap, while remaining negative, has also narrowed during this period, both from shrinking central bank balance sheet due to QT and higher B-star. Overall, the MCI has moved into the restrictive territory since the latter part of 2023, driven mainly by the positive interest rate gap.

The second approach, where the neutral balance sheet matters only for the liquidity effects, offers a different perspective. Panel (b) depicts the re-scaled MCI in this case, $\tilde{m}_t^b = (m_1 - m_1^*) + \frac{b_2}{b_1}(m_2 - m_{2,2007}) + \frac{b_3}{b_1} \max[0, ((1-\varepsilon)m_{2t} - m_{2t}^*]^2$ and each component. The interest rate policy component is identical to that in Panel (a) by design, aiding comparisons of balance sheet components. The asset-side component suggest more balance sheet policy accommodation than implied by the first approach, in part as it is unaffected by higher B-star. Meanwhile, the liability-side liquidity effects linked to B-star are generally muted, except for two brief episodes when the balance sheet size approached B-star. During these episodes, the tightening effects from the liability side partially offset the accommodation from the asset side, contributing to upward spikes in MCI. That said, the overall MCI stance is uniformly more accommodative than under the first approach, as the asset-side effects dominate.

Figure 13: Estimated weight and MCI with star variables

(a) MCI from Equation 9 ($\tilde{m}_t^a$) **(b)** MCI from Equation 10 ($\tilde{m}_t^b$)



Note: Panel(a) shows $\tilde{m}_t^a = (m_1 - m_1^*) + \frac{1-b}{b}(m_2 - m_2^*)$ and its components, where b is the median of the posterior distribution. Panel(b) shows $\tilde{m}_t^b = (m_1 - m_1^*) + \frac{b_2}{b_1}(m_2 - m_{2,2007}) + \frac{b_3}{b_1} \max[0, ((1-\varepsilon)m_{2t} - m_{2t}^*]^2$ and its components, where b_1, b_2, b_3 are the median of the posterior distribution. Coloured bars indicate the contributions from respective components.

The distinction between asset- and liability-side channels of balance sheet policy suggests that the choice of monetary operating framework, rather than simply a means to an end, may itself have important monetary policy implications. Under ample reserves system, the central bank must supply sufficient reserves to meet settlement needs, or else a sharp tightening in financial conditions would ensue. But in doing so, the central bank must maintain large asset holdings, which keep financial conditions more accommodative than otherwise. In other words, the balance sheet policy under ample reserves system cannot be truly neutral, and should always be considered when setting the interest rate policy.

Our quantitative results are subject to several important caveats. One is potential B-star measurement errors. Financial institutions may not be as informed about the *system*'s liquidity need as they are about their own. Indeed, the system's liquidity demand is shaped by multiple cyclical and structural factors, from existing leverage to regulation. And if the financial system can adapt over time to different levels of reserves (as it has done post-GFC), B-star may even be endogenous to central bank balance sheet policy itself. Survey respondents may also be reporting what they think the Federal Reserve *would* do with QT strategy (positive response) rather than what they think it *should* do to provide adequate liquidity (normative response). We also abstract from the implications of uneven reserve distribution, and indirect effects that changes in interests on reserves could have on financial conditions through the portfolio rebalance channel. Given these challenges, our quantitative exercises by no means provide a definitive answer to the question of balance sheet policy stance.[16] Our modest objectives are rather to flesh out some methods of integrating balance sheet policy considerations into overall monetary policy assessment, which can be refined in future research.

6 Global MCI

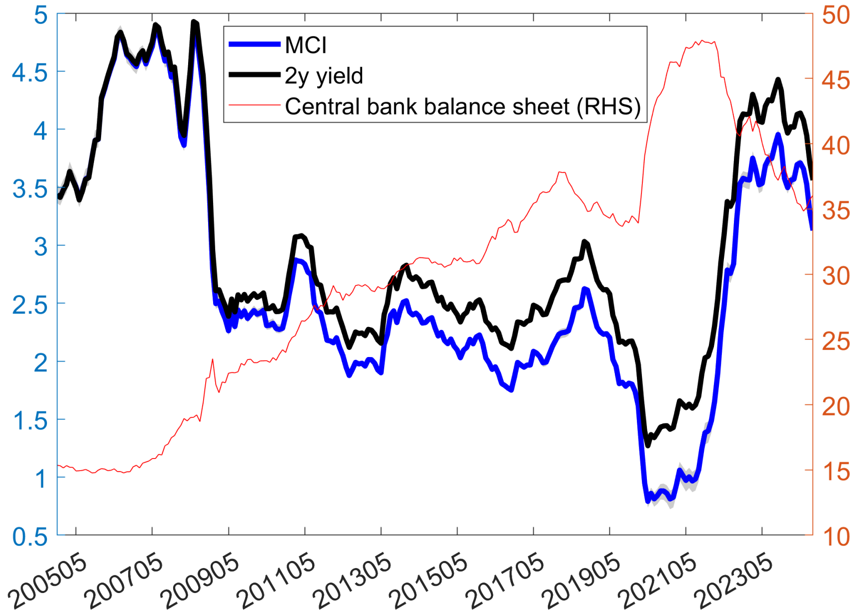
We have so far focused on the US case but the MCI framework can be applied to other economies or even groups of economies to study spillovers of conventional and unconventional monetary policies. We illustrate one such exercise by constructing a VAR consisting entirely of global variables. We use the global FCI from Goldman Sachs (Hatzius et al. (2017)), and compute GDP-weighted averages of inflation, output gap, and the 2-year yields from 32 countries (11 of which are advanced economies (AEs)). The global balance sheet variable is the ratio of total assets held by these 32 central banks to global trend GDP.[17] We then apply the same methodology to the global economy as a whole, with the resulting global MCI shown in Figure 14 based on the estimated weight of $b = 0.97$. The results suggest that increased asset purchases by all central banks since the GFC have kept global monetary policy conditions more accommodative than suggested by the global short-term rates alone. The additional accommodation reached its maximum around the pandemic, and was equivalent to about 50 basis points lower short-term rate globally. The results highlight the role unconventional measures in the broader international dimension of monetary policies. The impulse response functions and historical decomposition, reported in Appendix C, are broadly consistent with the baseline US results. In particular, MCI shocks partly explain swings in financial conditions and

[16] In practice, the policymaker has also been monitoring signs of liquidity shortage via indirect metrics such as the elasticity of the federal funds rate to reserve changes (reserve demand elasticity) – see Afonso et al. (2022). This measure suggests that reserves remain abundant as of April 2025.

[17] By including FX intervention, the measure captures the idea that increased holding of foreign assets by central banks can compress yields in key markets and ease financial conditions globally via spillovers.

inflation in the post-pandemic period.

Figure 14: Global MCI



Note: The figure shows results with global variables. For global FCI, we use the Goldman Sachs global financial conditions index. For global 2-year yield, inflation and output gap, we use the GDP-weighted average of 32 countries (11 AEs and 21 EMEs). We compute the global central bank balance sheet size as the total assets of central banks from these 32 countries divided by the trend of global GDP. Blue line is the global MCI, which is shown alongside the global 2-year yield (black line) and the global central bank balance sheet size (red line). The shaded areas indicate respective 16%-84% confidence intervals.)

The MCI framework can also be applied to individual countries where the central banks have engaged in large-scale asset purchases. This includes cases where balance sheets have expanded from FX intervention, under the assumption that foreign asset holdings induce a stock effect on exchange rates (e.g. via portfolio balance channel as in Gabaix and Maggiori (2015)). In this instance, our methodology is closely related to the older definition of MCI as a weighted average between exchange rate and short-term interest rate. In the case of domestic asset purchases, our MCI framework and interpretation readily apply. The MCI weight would generally vary with context, depending on the types of assets purchased and strength of transmission mechanisms among others. Country-specific applications would also warrant tailored selection of variables to include in the VAR, which we leave for future works.

7 Conclusion

Central bank balance sheet have become an integral instrument of macroeconomic stabilisation policies, raising questions about how they should interact with monetary policy interest rates. Ample evidence suggests that increases in the central bank balance sheet provide effective additional accommodation, particularly when policy rates are constrained by the ELB. At the same time, central banks have approached the unwinding of balance sheet policies with far greater caution, often emphasising a predictable and passive process–famously likened to 'watching paint dry'. Predictability does not imply irrelevance, however. Even in the absence of surprises, the stock effects of an expanded central bank balance sheet may continue to shape financial conditions and macroeconomic outcomes. Accounting for this influence is essential for a comprehensive assessment of the overall stance of monetary policy.

This paper introduces a new monetary policy conditions index (MCI), a simple measure that captures the effects of both conventional and unconventional policy tools. Unlike the shadow rate, the MCI provides a consistent metric to assess the stance of monetary policy across different regimes even when the short-term rates and balance sheet policies are both active. Through several empirical applications, we demonstrate how an MCI-based macroeconomic time-series model helps address key policy questions, offering a more robust framework for understanding the transmission of monetary policy including unconventional measures. At the current juncture, the MCI highlights the persistence of large central bank balance sheets, either considering the US or at the global level, loosen the stances of monetary policy.

These findings have important policy implications. Balance sheet policies are not emergency policy tools that, once deployed, can be withdrawn at will. In practice, their gradual unwinding means their effects on financial markets and the broader economy can linger long after the emergency needs have passed. A better understanding of these persistent effects would help central banks anticipate and internalise potential unintended consequences before embarking on balance sheet policies. It would also enable them to better offset these effects ex post through the policy interest rates when necessary. Our proposed MCI provides one simple framework to guide this process, helping policymakers coordinate their balance sheet and interest rate policies more systematically.

References

Afonso, G., D. Giannone, G. La Spada, and J. C. Williams (2022): "Scarce, abundant, or ample? A time-varying model of the reserve demand curve," *Federal Reserve Bank of New York Staff Reports*.

Ajello, A., M. Cavallo, G. Favara, W. B. Peterman, J. W. Schindler IV, and N. R. Sinha (2023): "A new index to measure US financial conditions," *FEDS Notes*.

Arias, J. E., J. F. Rubio-Ramírez, and D. F. Waggoner (2018): "Inference Based on Structural Vector Autoregressions Identified With Sign and Zero Restrictions: Theory and Applications," *Econometrica*, 86, 685–720.

Bank for International Settlements (2024): "Monetary policy in the 21st century: lessons learned and challenges ahead," BIS Annual Economic Report, Chapter II.

Bauer, M. D. and G. D. Rudebusch (2014): "The signaling channel for Federal Reserve bond purchases," *International Journal of Central Banking*, 10, 233–289.

Benigno, G., B. Hofmann, G. N. Barrau, and D. Sandri (2024): "Quo vadis, r*? The natural rate of interest after the pandemic," *BIS Quarterly Review*, 4, 17–30.

Black, F. (1995): "Interest rates as options," *Journal of Finance*, 50, 1371–1376.

Boeckx, J., M. Dossche, and G. Peersman (2017): "Effectiveness and Transmission of the ECB's Balance Sheet Policies," *International Journal of Central Banking*, 13, 297–333.

Borio, C., P. Disyatat, and A. Schrimpf (2024): "The double-faced demand for bank reserves and its implications," VoxEU, February 15.

Brave, S. A. and D. Kelley (2017): "Introducing the Chicago Fed's New Adjusted National Financial Conditions Index," *Chicago Fed Letter*.

Bu, C., J. Rogers, and W. Wu (2021): "A unified measure of Fed monetary policy shocks," *Journal of Monetary Economics*, 118, 331–349.

Committee on the Global Financial System (2019): "Unconventional monetary policy tools: a cross-country analysis," CGFS Papers No. 63.

Crawley, E., E. Gagnon, J. Hebden, and J. Trevino (2022): "Substitutability between Balance Sheet Reductions and Policy Rate Hikes: Some Illustrations and a Discussion," *FEDS Notes*.

D'Amico, S. and T. B. King (2013): "Flow and stock effects of large-scale Treasury purchases: Evidence on the importance of local supply," *Journal of Financial Economics*, 108, 425–448.

Doh, T. and J. Choi (2016): "Measuring the stance of monetary policy on and off the zero lower bound," *Federal Reserve Bank of Kansas City, Economic Review*, 101, 5–24.

Du, W., K. Forbes, and M. N. Luzzetti (2024): "Quantitative Tightening Around the Globe: What Have We Learned?" Tech. rep., National Bureau of Economic Research.

Eren, E., A. Schrimpf, and D. Xia (2023): "The effects of quantitative easing on long-term yields: a demand system approach," *BIS Working Paper No. 1100*.

Federal Open Market Committee (2016): "Long-Run Framework: Macroeconomic Considerations of Balance Sheet Policies," FOMC Memorandum.

Gabaix, X. and M. Maggiori (2015): "International Liquidity and Exchange Rate Dynamics *," *The Quarterly Journal of Economics*, 130, 1369–1420.

Gagnon, J., M. Raskin, J. Remache, and B. Sack (2011): "Large-scale asset purchases by the Federal Reserve: did they work?" *Federal Reserve Bank of New York Economic Policy Review*, 17, 41–59.

Gambacorta, L., B. Hofmann, and G. Peersman (2014): "The effectiveness of unconventional monetary policy at the zero lower bound: A cross-country analysis," *Journal of Money, Credit and Banking*, 46, 615–642.

Gertler, M. and P. Karadi (2015): "Monetary policy surprises, credit costs, and economic activity," *American Economic Journal: Macroeconomics*, 7, 44–76.

Hatzius, J., S. Stehn, N. Fawcett, and K. Fishman (2017): "Our new G10 financial conditions indices," *Goldman Sachs Global Economics Analyst*.

Holston, K., T. Laubach, and J. C. Williams (2017): "Measuring the natural rate of interest: International trends and determinants," *Journal of international economics*, 108, S59–S75.

Kandrac, J. and B. Schlusche (2013): "Flow effects of large-scale asset purchases," *Economics Letters*, 121, 330–335.

Kearns, J., A. Schrimpf, and F. D. Xia (2023): "Explaining monetary spillovers: The matrix reloaded," *Journal of Money, Credit and Banking*, 55, 1535–1568.

Kleibergen, F. and R. Paap (2006): "Generalized reduced rank tests using the singular value decomposition," *Journal of Econometrics*, 133, 97–126.

Krishnamurthy, A. and A. Vissing-Jorgensen (2011): "The effects of quantitative easing on interest rates: channels and implications for policy," *Brookings Papers on Economic Activity*, 2011, 215–287.

Li, C. and M. Wei (2013): "Term structure modeling with supply factors and the Federal Reserve's large-scale asset purchase programs," *International Journal of Central Banking*, 9, 3–39.

Logan, L. K. (2023): "The Fed listens: Community voices on the economy and the Federal Reserve," Speech at the Dallas Fed, San Antonio, TX, available at https://www.dallasfed.org/news/speeches/logan/2023/lkl231110 [Accessed 7 April 2025].

Lombardi, M. J. and F. Zhu (2018): "A shadow policy rate to calibrate US monetary policy at the zero lower bound," *56th issue (December 2018) of the International Journal of Central Banking.*

Lopez-Salido, D. and A. Vissing-Jorgensen (2021): "Reserve demand, interest rate control and quantitative tightening," *Mimeo.*

Swanson, E. T. (2021): "Measuring the effects of federal reserve forward guidance and asset purchases on financial markets," *Journal of Monetary Economics*, 118, 32–53.

Uhlig, H. (2017): *Shocks, Sign Restrictions, and Identification*, Cambridge University Press, 95–127, Econometric Society Monographs.

Wei, B. (2022): "Quantifying 'Quantitative Tightening'(QT): How Many Rate Hikes Is QT Equivalent To?" *Federal Reserve Bank of Atlanta working papers.*

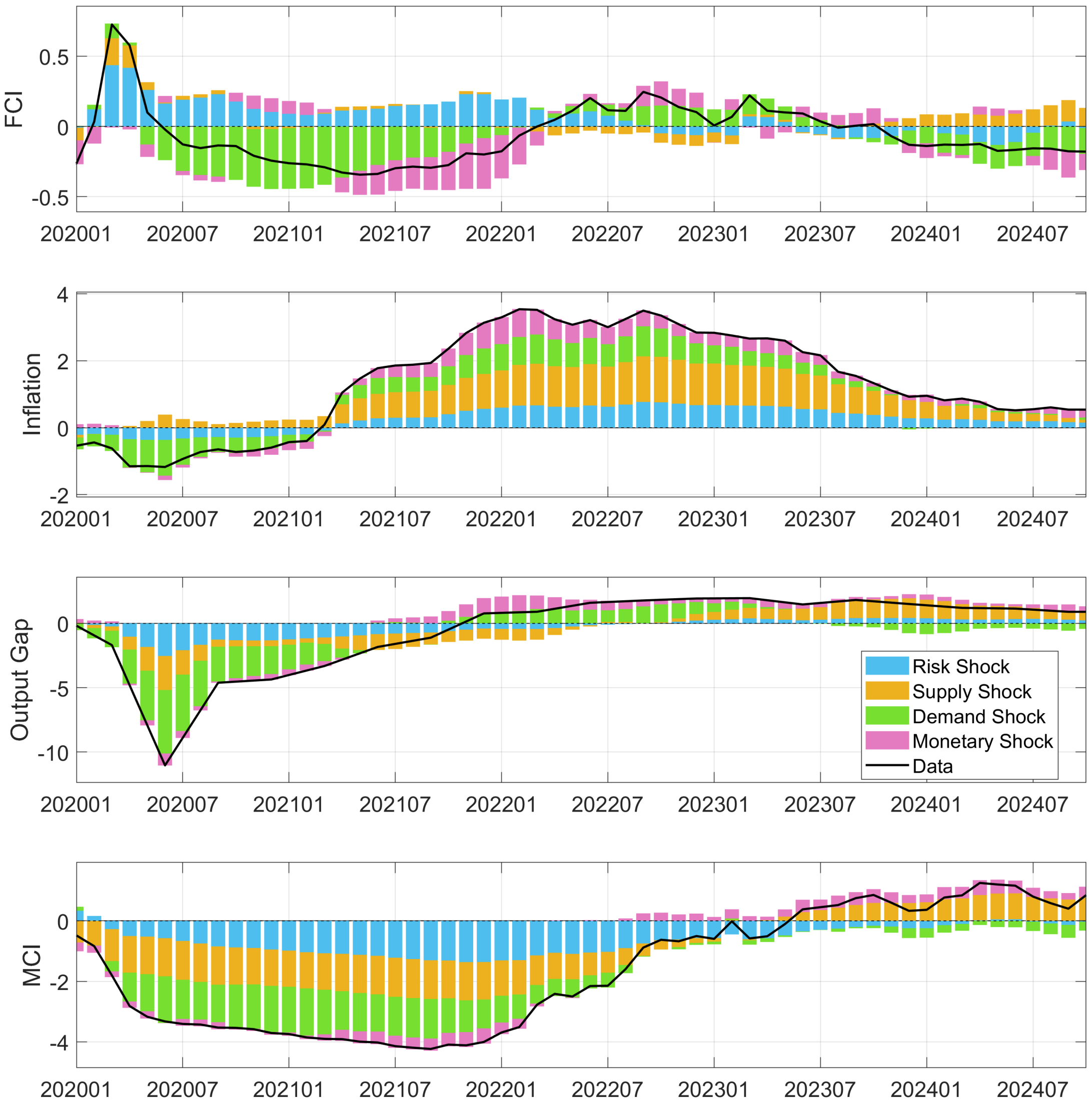
Wu, J. C. and F. D. Xia (2016): "Measuring the macroeconomic impact of monetary policy at the zero lower bound," *Journal of Money, Credit and Banking*, 48, 253–291.

Wu, J. C., Y. Xie, and J. Zhang (2024): "Does Unconventional Monetary and Fiscal Policy Contribute to the COVID Inflation Surge?" *NBER Working Paper 33044.*

Appendix

Appendix A   Historical decomposition

Figure A.1: Historical decomposition over recent sample



Note: The figure shows the historical decomposition of endogenous variables, differentiating contributions from four structural shocks as coloured bars. Each bar is the mean of historical decompositions across all accepted draws of Bayesian estimates.

Appendix B   MCI and high-frequency monetary policy shocks

One popular strategy for identifying monetary policy shocks is the use of high-frequency monetary policy shocks, defined as asset price changes within a narrow window around policy announcements. For example, see Gertler and Karadi (2015). A key challenge with this approach, when short-term interest rates—such as one- or two-year rates—are used as policy indicators, is that these high-frequency shocks are often found to be weak instruments. This is not surprising, as many high-frequency monetary policy shocks capture influences from changes to both policy rate and balance sheet policies, while short-term interest rates primarily reflect the former.

Could our MCI make high-frequency monetary policy shocks more effective and usable for researchers as external instruments? To explore this, we test whether several high-frequency monetary policy shocks are strong instruments for various monetary policy indicators, including one- and two-year interest rates, the SOMA-to-trend-GDP ratio, and our MCI. We consider three sets of monetary policy shocks that capture both conventional and unconventional policies. The first set is from Bu et al. (2021), who develop a heteroskedasticity-based partial least squares approach combined with Fama-MacBeth-style regressions to identify a common U.S. monetary policy surprise that reflects both conventional and unconventional policy news. The second set is from Swanson (2021), who uses factor analysis on changes in various asset prices—such as fixed-income instruments along the term structure—around monetary policy announcements to separately identify surprise changes in the federal funds rate, forward guidance, and large-scale asset purchases (LSAPs). The third set is from Kearns et al. (2023), who share a similar goal with Swanson (2021) but adopt a simpler approach to construct target rate, path, and long-rate surprises.

Table 2 reports the Kleibergen-Paap Wald rk F-statistic, a robust measure for assessing the strength of instrumental variables in IV regression models (Kleibergen and Paap (2006)). The null hypothesis is that the instruments are weak, meaning that high-frequency monetary policy shocks do not have sufficient explanatory power for the monetary policy indicator. A higher F-statistic indicates a greater likelihood of rejecting the null hypothesis. Across all three sets of monetary policy shocks, the MCI consistently delivers the highest F-statistics, suggesting that for these monetary policy shocks, the null of weak instruments is more likely to be rejected when the MCI is used as the monetary policy variable. In the case of shocks from Kearns et al. (2023), they turn out to be acceptable instruments for MCI with maximal 25% size distortion.

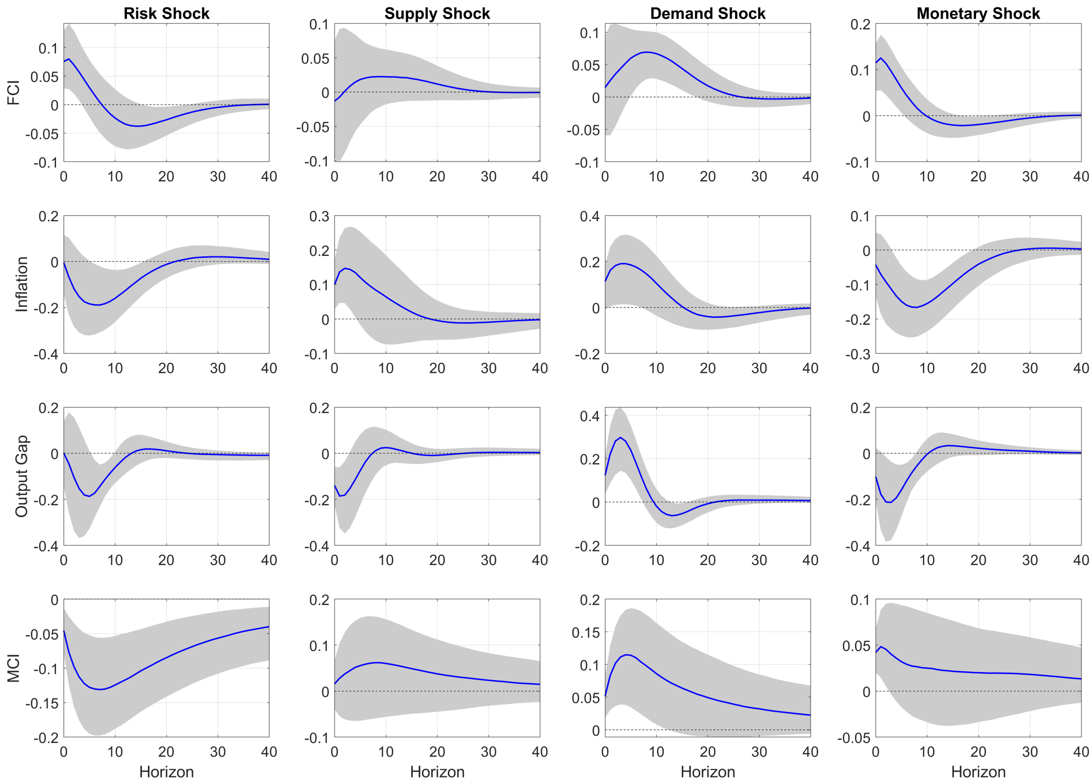
Table 2: Testing high-frequency monetary policy shocks as external instruments

	F statistics				critical values for IV size			
	one-year rate	two-year rate	SOMA-to-GDP ratio	MCI	25%	20%	15%	10%
Bu et al. (2021)	0.42	3.79	5.16	5.35	5.53	6.66	8.96	16.38
Swanson (2021)	1.58	2.57	3.01	4.27	7.80	9.54	12.83	22.30
Kearns et al. (2023)	5.31	4.93	1.44	8.39	7.80	9.54	12.83	22.30

Note: The table reports the Kleibergen-Paap Wald rk F-statistic, which is used to test whether the instrumental variables are weak. Higher F-statistic values indicate a greater likelihood of rejecting the null hypothesis that the instrumental variables are weak.

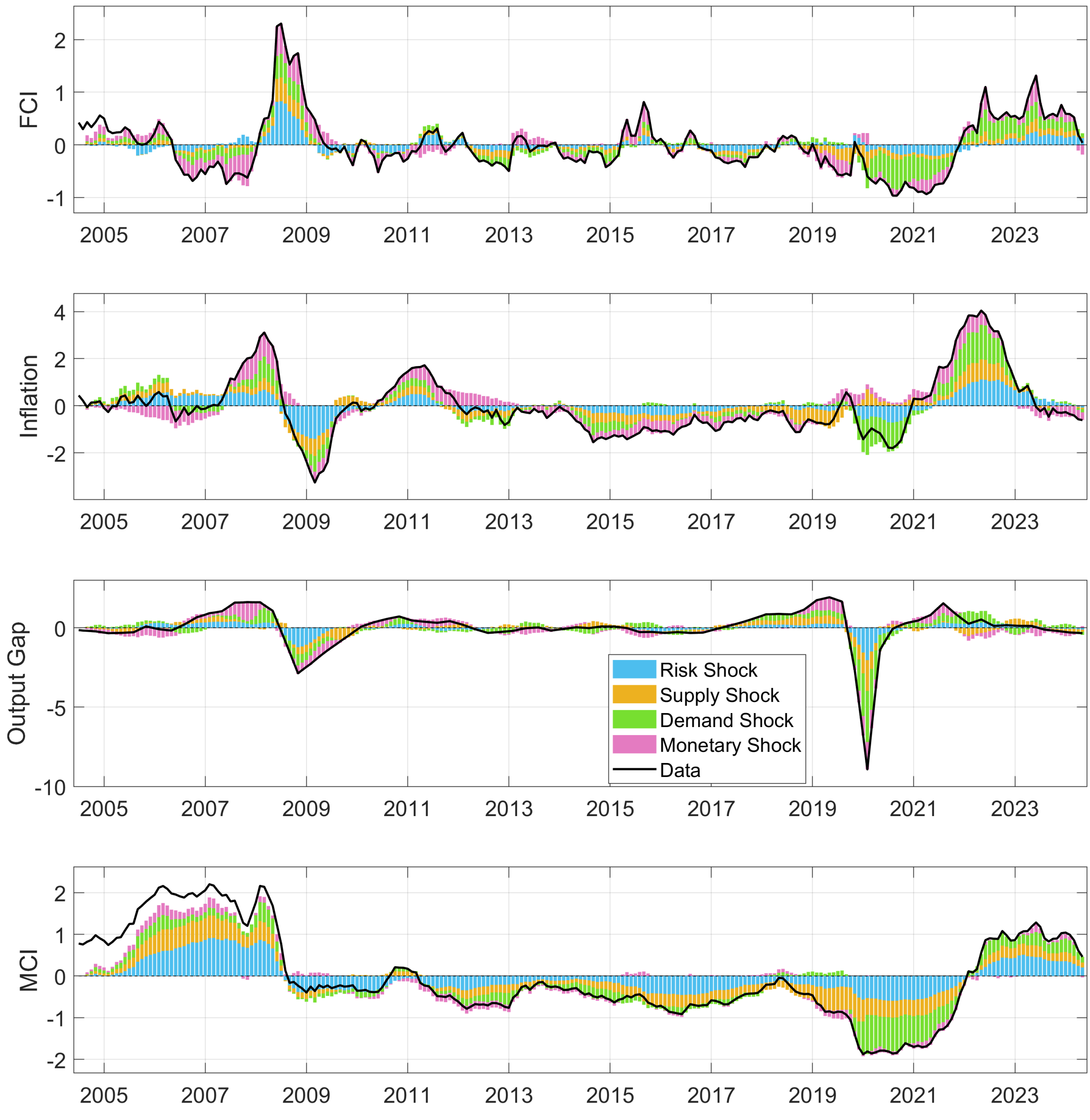
Appendix C Global MCI

Figure C.2: Impulse response functions under the global model



Note: The figure shows the impulse response functions under the global model, with sources of shocks in columns and endogenous variables in rows. Horizons on the x-axis are in months. Blue lines are median impulse responses across all accepted draws of Bayesian estimates. Gray shades represent the one standard deviation band.

Figure C.3: Historical decomposition under the global model



Note: The figure shows the historical decomposition of endogenous variables under the global model, differentiating contributions from four structural shocks as coloured bars. Each bar is the mean of historical decompositions across all accepted draws of Bayesian estimates.

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