Monetary Policy Trade-offs Amid Global Supply Chain Disruptions*

Luis Hernández-Román†
Banco de México

Abstract

This paper employs a proxy structural vector autoregressive (SVAR) model to examine the Federal Reserve's response to global supply chain shocks and their aggregate propagation under two counterfactual policy rules. Historically, the Fed has overlooked initial price surges, presumably favouring output, before adjusting its policy in response to persistent inflation. Stabilising inflation would entail an initial tightening and a mild recession, but ultimately more stable inflation expectations. Conversely, minimising a dual-mandate loss function—whether through inflation targeting (IT) or average inflation targeting (AIT)—calls for a more accommodative initial policy followed by greater subsequent tightening compared to the actual policy rule. The AIT policy rule, prioritising output and tolerating higher inflation more than the IT policy rule, would require a looser policy stance. However, prices being more sensitive than output to GSC disruptions eventually led to a much more contractionary policy under the AIT policy rule, worsening the inflation-output trade-off.

Keywords: inflation, supply chain disruptions, optimal monetary policy, policy counterfactuals, proxy SVAR
JEL codes: E31, E32, E43, E52, E58

*I am indebted to my advisors Ana Galvão and Ivan Petrella for invaluable discussions, guidance, and support throughout this project. I also thank Boragan Aruoba, Julio Carrillo, Efrem Castelnuovo, Marija Vukotić, and Jonathan Wright for their valuable comments and suggestions.
†Email address: lhernadez@banxico.org.mx. Personal website: www.luishdzroman.com.

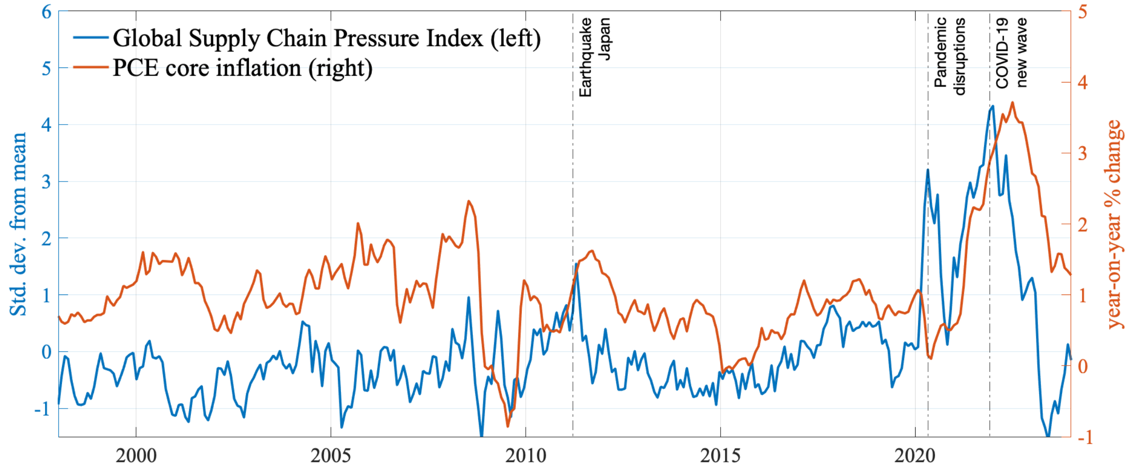
1 Introduction

The unprecedented disruptions in global supply chains (GSC) resulting from the COVID-19 pandemic, combined with a strong demand supported by U.S. government stimulus policies and shifts in demand between services and goods sectors during the pandemic's recovery phase, led to inflationary pressures, particularly in the goods sector (see, e.g. Reis, 2022; Blanchard and Bernanke, 2023, among many others). Figure 1 displays the evolution of GSC disruptions, as captured by the Global Supply Chain Pressure Index (GSCPI) of Benigno et al. (2022), along with U.S. core PCE inflation. This figure shows an apparent positive correlation not restricted only to the post-COVID-19 period.

Against this background, a growing number of empirical studies, as documented below, have examined the aggregate effects of GSC shocks. These shocks capture sudden decreases in the supply provision or the functioning of supply chains stemming from adverse events such as natural disasters, e.g. a hurricane or earthquake, geopolitical events, and pandemics (see, e.g. Burriel et al., 2023; Clark and Gordon, 2023). The evidence so far, for both the U.S. and the Euro area, indicates that GSC shocks act as supply shocks, decreasing output and pushing up consumer prices. However, unlike "traditional" aggregate supply shocks, this "new" type of supply shock, as labelled by Banbura et al. (2023), is characterised by having a highly persistent effect on core inflation. These studies also document the significant role of these shocks in accounting for the recent inflation surges in the U.S. and the Euro area.

A natural question arises: How should central banks respond to GSC shocks? Central banks often face a dilemma: Should they *look through* supply shocks temporarily, at the risk of de-anchoring inflation expectations? Or should they *react* to them by promptly tightening monetary policy to maintain anchored expectations, even at the potential cost of exacerbating the economic downturn? The appropriate monetary policy response has become a focal point for policymakers, as recently highlighted by the Federal Reserve Chairman Jeremy Powell: *"[...] for many years, it has been generally thought that monetary policy should limit*

Figure 1: Global Supply Chain Pressures and U.S. Core Inflation



Note: The figure shows the monthly Global Supply Chain Pressure Index (GSCPI), constructed by Benigno et al. (2022), alongside U.S. PCE core inflation. The GSCPI is standardized. The index, available since 1998, spikes during adverse episodes of global supply disruptions associated with natural disasters and the pandemic, among others. Sample period from 1998M1 to 2023M12.

its response to, or "look through," supply shocks to the extent that they are temporary and idiosyncratic. [...] Our experience since 2020 highlights some limits of that thinking."[1]

This paper contributes to this discussion by examining this dilemma empirically focusing on the US experience, estimating the monetary policy response to GSC shocks and the aggregate propagation of those shocks under two counterfactual monetary policy rules that stabilise inflation and minimise a simple dual-mandate loss function. While growing theoretical contributions, as detailed below, have explored the implications of GSC for monetary policy, little empirical evidence exists on how policymakers respond to GSC disruptions and whether that matters.

Using a state-of-the-art structural vector autoregressive (SVAR) model identified with external instruments to provide causal evidence of GSC disruptions, I first document that the Federal Reserve (Fed) historically has looked through initial GSC-driven price surges and even adopted a loose policy, presumably to stabilise output, before adjusting its policy in the face of persistent inflation. The dynamics of this monetary policy response, which I will refer to as the *baseline* policy response, resonates with the narrative provided by Reis (2022)

[1]Jerome Powell, "Monetary Policy Challenges in a Global Economy," IMF, Nov. 2023. For further discussion on this subject, see also Carstens (2022a,b).

explaining the inflation surge in 2021-22. Reis attributes it to challenges in interpreting GSC shocks amidst uncertainty, leading to prolonged expansionary policy based on the belief that inflation expectations were stable and rises in inflation temporary. Reis also notes that the Fed's shift in 2020 to average inflation targeting (AIT) over inflation targeting (IT) (see Powell, 2020), could have increased tolerance for higher inflation.

Further, I study the counterfactual propagation of GSC shocks under two alternative monetary policy rules using McKay and Wolf (2023)'s sufficient statistics approach, robust to the Lucas critique. The first counterfactual, based on a policy rule that stabilises inflation, would have entailed an initial policy tightening, a mild front-loaded recession, but resulting in more stable inflation expectations. The sensitivity of prices to GSC disruptions and relative inelasticity of output align with theoretical models emphasizing capacity constraints' role in generating high inflation with minimal output, implying state dependence in the trade-off for monetary policy (Bai et al., 2024; Benigno et al., 2022; Blanchard and Bernanke, 2023; Comin et al., 2023). This result indicates that that supply chain-induced inflation can be effectively managed without significant economic downturns under this alternate rule.

The second counterfactual examines a policy rule that minimises a simple dual-mandate loss function. For this loss, I recover two optimal rules that target either inflation or *average* inflation. Under these scenarios, an immediately more accommodative policy, followed by a stronger monetary tightening, relative to the baseline policy response, would have been necessary to fulfil the dual mandate. The AIT optimal rule seems to prioritise output and tolerate higher inflation more than the IT optimal rule, requiring a looser initial policy. Prices being highly sensitive to GSC disruptions eventually lead to a much more contractionary policy under the AIT optimal rule, worsening the inflation-output trade-off.

In more detail, I estimate a vector autoregressive (SVAR) model based on external instruments, commonly known as Proxy SVAR or IV SVAR (Mertens and Ravn, 2013; Stock and Watson, 2018). The VAR includes the GSCPI index of Benigno et al. (2022) along with a broad array of U.S. macroeconomic and financial variables in order to speak to the theoretical literature on the aggregate effects of GSC disruptions. To identify a GSC shock, I use the residuals of the news-based Supply Bottleneck Index (SBI) for the U.S., constructed by

Burriel et al. (2023), as an external instrument for the GSCPI index. The SBI index provides a consistent narrative of both domestic and global supply-side disruptions episodes, making it an ideal indicator to be used as an instrument. I estimate the model on monthly data spanning from 1998 to 2023, the period for which the GSCPI index is available. Finally, I use Bayesian techniques to efficiently deal with the dataset.

I then construct counterfactual scenarios in which the Fed deviates from its actual policy rule and stabilises inflation or minimises a simple dual-mandate loss function, considering both IT and AIT optimal policies for the latter. McKay and Wolf (2023) demonstrate that it is possible to derive policy-rule counterfactuals in a VAR model using monetary policy news shocks at time t, even without full knowledge of the underlying structural model. To enact these counterfactuals, I further identify conventional monetary policy and forward guidance shocks using the monetary policy surprise series of Jarociński (2024) as external instruments. Following McKay and Wolf (2023), I then choose the size of these shocks so that, when they materialise together with a GSC shock in period t, they counterbalance the responses of the variables of interest, i.e. inflation and output, as much as possible.

This paper is organised as follows. Section 2 reviews the related literature. Section 3 describes the empirical methodology and the identification of GSC shocks. Section 4 examines the propagation of GSC shocks and the Fed's response to theses shocks. Section 5 presents the VAR-based policy counterfactuals. Section 6 discuses some robustness check. Section 7 concludes.

2 Literature Review

This paper is connected to three strands of the literature. First, it is related to post-pandemic empirical literature that investigates the causal macroeconomic effects of GSC disruptions. This literature is still in its infancy, as analysing these effects requires measuring the conditions of global supply chains, which is not straightforward due to their complex structure. Recent studies have addressed this challenge by either employing diverse proxies or constructing new measures. Some focus on shipping costs (e.g., Attinasi et al., 2021; Carrière-

Swallow et al., 2023), captured by indices such as the Baltic Dry Index (BDI) or the Harpex Index for maritime transport. Others, such as Schuler et al. (2022) and Clark and Gordon (2023), use the Purchasing Managers' Index (PMI) surveys on delivery times, backlogs, or purchased stocks. Acknowledging that these proxies capture both supply and demand imbalances, Benigno et al. (2022) combine them, focusing on seven interlinked countries, to construct a summary indicator, the Global Supply Chain Pressure Index (GSCPI), purged of demand-side factors.[2] In addition, Burriel et al. (2023) and Bai et al. (2024) develop new indicators using newspaper articles and maritime satellite data, respectively.

Embedding these measures into VAR models, with a primary focus on the U.S. and the Euro area, these papers, alongside others like Ascari et al. (2023), Banbura et al. (2023), De Santis (2023), Finck and Tillmann (2022), and Kabaca and Tuzcuoglu (2023), identify GSC shocks using either recursive identification or a combination of sign and narrative restrictions following the approach of Antolín-Díaz et al. (2021). The sign restrictions on impulse response functions (IRFs) and the choice of narrative restrictions vary across studies. Despite these differences, a consistent finding emerges: GSC shocks act as supply shocks, resulting in a decrease in output and upward pressure on consumer prices. Notably, the effect on the latter tends to be highly persistent compared to more conventional supply shocks. This paper adds to this literature by using an alternative identification approach based on a Proxy-SVAR and by examining the transmission of GSC shocks under counterfactual monetary policy rules, following the approach McKay and Wolf (2023), with a specific focus on the U.S.

Second, this paper adds to the small but growing empirical literature on how global supply chain conditions influence the transmission of monetary policy shocks.[3] In a nonlinear local projection framework, Laumer and Schaffer (2023) provide pre-pandemic evidence indicating that intensified GSC pressures amplify the standard effects of US monetary policy on inflation and output. They argue that this amplification is attributed to credit costs re-

[2]The countries considered are China, the Euro area, Japan, South Korea, Taiwan, the United Kingdom, and the United States.

[3]Some relevant and related theoretical contributions include Ozdagli and Weber (2017), Pasten et al. (2020), and Ghassibe (2021), showing that the existence of input-output linkages in production networks amplify the effects of monetary policy shocks. This is because the presence of production networks creates complementarities in firms' price setting.

acting more strongly to monetary policy shocks during times of global supply chain distress. Employing a Threshold VAR, Bai et al. (2024) show that when global supply chains are disrupted, inflation becomes more responsive to U.S. monetary policy shocks, while output remains relatively inelastic. This outcome aligns with their theoretical model, where an excess capacity for producers and a shortage of supplies for retailers result in significant price increases and heightened search frictions, limiting output during supply chain disruptions. The evidence presented in this paper, through VAR-based policy counterfactuals, is in line with these studies, demonstrating that monetary policy is more effective in taming inflation amid GSC disruptions. Additionally, I contribute to this literature by further quantifying the trade-offs between inflation and output faced by policymakers depending on the monetary policy rule they adopt.

Finally, this paper relates to the literature on the optimal monetary policy response or design under global supply chains, which has been primarily explored through theoretical models. Theoretical contributions based on New Keynesian models with multiple stages of production and focusing on optimal design include Gong et al. (2016), Wei and Xie (2020), La'O and Tahbaz-Salehi (2022), and Rubbo (2023). Their results imply that targeting alternative indices rather than CPI inflation alone leads to smaller welfare losses. In the same vein, but considering a standard Taylor rule, Ascari et al. (2023) show that the macroeconomic impact of GSC shocks hinges on the degree of global value chain (GVC) participation. Consequently, optimal monetary policy faces significant inflation and output trade-offs when GVC participation is high, calling for a less aggressive monetary policy tightening. To my knowledge, this is the first empirical contribution to examine the optimal response of monetary policy amid GSC based on the recent Lucas-robust counterfactual framework proposed by McKay and Wolf (2023). In addition, I also consider an optimal rule incorporating the recent change in the Federal Reserve's policy framework, replacing inflation targeting with average inflation targeting to achieve its dual mandate (see Powell, 2020).

3 Empirical Strategy

This section outlines the identification strategy based on external instruments, commonly known as Proxy SVAR or IV SVAR (Mertens and Ravn, 2013; Stock and Watson, 2018). For ease of exposition, this section focuses on discussing the identification of GSC shocks, as it is the key shock of interest. Additional details on how I identify two U.S. monetary policy shocks essential for the counterfactual analysis, are presented in Section 5.

3.1 Proxy Structural Vector Autoregression (SVAR)

Reduced-form VAR. Consider the following Structural Vector Autoregression (SVAR) model of the form

$$\boldsymbol{A}_0\boldsymbol{y}_t = \boldsymbol{a} + \boldsymbol{A}_1\boldsymbol{y}_{t-1} + \ldots + \boldsymbol{A}_p\boldsymbol{y}_{t-p} + \boldsymbol{\varepsilon}_t, \tag{1}$$

where p is the lag order, $\boldsymbol{y}_t$ is an $n \times 1$ vector of endogenous variables, $\boldsymbol{a}$ is an $n \times 1$ vector of constants, and $\boldsymbol{A}_1, \ldots, \boldsymbol{A}_p$ are $n \times n$ coefficient matrices. $\boldsymbol{\varepsilon}_t$ is an $n \times 1$ vector of structural shocks and $\boldsymbol{A}_0$ is a non-singular $n \times n$ structural impact matrix. By definition, the structural shocks are mutually uncorrelated, with $\text{var}(\boldsymbol{\varepsilon}_t) = \boldsymbol{\Omega}$ diagonal. Denoting $\boldsymbol{S} = \boldsymbol{A}_0^{-1}$, the reduced-form version of the SVAR model is given by

$$\boldsymbol{y}_t = \boldsymbol{b} + \boldsymbol{B}_1\boldsymbol{y}_{t-1} + \ldots + \boldsymbol{B}_p\boldsymbol{y}_{t-p} + \boldsymbol{u}_t, \tag{2}$$

where $\boldsymbol{b} = \boldsymbol{S}\boldsymbol{a}$ is an $n \times 1$ vector of constants and $\boldsymbol{B}_j = \boldsymbol{S}\boldsymbol{A}_j$, $1 \leq j \leq p$, are $n \times n$ coefficient matrices. The $n \times 1$ vector of reduced-form innovations $\boldsymbol{u}_t$ is related to the structural shocks $\boldsymbol{\varepsilon}_t$ via a linear mapping

$$\boldsymbol{u}_t = \boldsymbol{S}\boldsymbol{\varepsilon}_t, \tag{3}$$

with covariance matrix $\text{var}(\boldsymbol{u}_t) = \boldsymbol{\Sigma} = \boldsymbol{S}\boldsymbol{\Omega}\boldsymbol{S}'$. In the literature, equation (3) is known as the invertibility assumption.

Identification strategy. The SVAR model in equation (1) faces an identification challenge as the covariance matrix $\boldsymbol{\Sigma}$ only provides $n(n+1)/2$ restrictions to identify the n^2 free parameters in $\boldsymbol{S}$. Therefore, we have to impose restrictions on the structural parameters to solve the identification problem. In this study, I resort to SVAR identification based on external instruments, commonly known as Proxy SVAR or IV SVAR (Stock and Watson, 2012; Mertens and Ravn, 2013).

Without loss of generality, let us denote the shock of interest as the first shock in the SVAR (1), $\varepsilon_{1,t}$. The aim is to identify the structural impact vector $\boldsymbol{s}_1$, which corresponds to the first column of matrix $\boldsymbol{S}$. The identification strategy exploits external instruments to separate exogenous variation in the innovations of the instrumented variable, $y_{1,t}$, attributed to the structural shock of interest. Suppose there is an external instrument available, z_t. For z_t to be a valid instrument, it must satisfy two conditions:

$$\text{Relevance condition:} \quad \mathbb{E}[z_t \varepsilon_{1,t}] = \alpha \neq 0, \tag{4a}$$

$$\text{Exogeneity condition:} \quad \mathbb{E}[z_t \boldsymbol{\varepsilon}_{2:n,t}] = \mathbf{0}, \tag{4b}$$

where $\varepsilon_{1,t}$ is the shock of interest and $\boldsymbol{\varepsilon}_{2:n,t}$ is a $(n-1) \times 1$ vector consisting of the other structural shocks. The first condition implies that the instrument is correlated with the true underlying structural shock. The second condition requires that the instrument is not correlated with any other structural shock.

Under conditions (4a) and (4b), along with the invertibility requirement (3), $\boldsymbol{s}_1$ is identified up to sign and scale:

$$\mathbb{E}[z_t \boldsymbol{u}_t] = \boldsymbol{s}_1 \mathbb{E}[z_t \varepsilon_{1,t}] = \boldsymbol{s}_1 \alpha. \tag{5}$$

It is easy to show that, this equation leads to

$$\frac{\boldsymbol{s}_{2:n,1}}{s_{1,1}} = \frac{\mathbb{E}[z_t \boldsymbol{u}_{2:n,t}]}{\mathbb{E}[z_t u_{1,t}]}, \tag{6}$$

provided that $\mathbb{E}[z_t u_{1,t}] \neq 0$. The scale $s_{1,1}$ is then normalised, subject to $\boldsymbol{\Sigma} = \boldsymbol{S}\boldsymbol{\Omega}\boldsymbol{S}'$. Setting $\boldsymbol{\Omega} = \boldsymbol{I}_n$ implies that a unit positive value of $\varepsilon_{1,t}$ induces a one standard deviation positive effect on the instrumented variable $y_{1,t}$, i.e. $s_{1,1} = 1$.

While the majority of studies employing Proxy-SVAR analysis typically use one instrument to identify one structural shock, a growing literature explores the case where multiple instruments are employed to identify multiple structural shocks (see e.g. Arias et al., 2021, and all the references therein). Achieving point identification in this case, however, may necessitate imposing additional and potentially controversial identifying restrictions (Giacomini et al., 2022). In this study, given the availability of three external instruments to identify three different shocks, I consider each of the three shocks and instruments separately, one at a time. The instruments being mutually orthogonal, there is no distinction between estimating the effects of the shocks individually versus jointly.[4]

Bayesian estimation. I estimate the reduced-form VAR(p) using Bayesian techniques. In particular, I assume a normal-inverse-Wishart prior distribution over the reduced-form parameters of the form:

$$\boldsymbol{\Sigma} \sim \mathcal{IW}(\boldsymbol{S}_0, \alpha_0) \qquad \text{and} \qquad \boldsymbol{B}|\boldsymbol{\Sigma} \sim \mathcal{N}(\boldsymbol{B}_0, \boldsymbol{\Sigma} \otimes \boldsymbol{\Omega}_0) \tag{7}$$

where $\boldsymbol{B} = \mathrm{vec}([\boldsymbol{b}, \boldsymbol{B}_1, \ldots, \boldsymbol{B}_p]')$. The degrees of freedom of the inverse-Wishart distribution are set to $\alpha_0 = n+2$, a value that guarantees the existence of the scale matrix $\boldsymbol{S}_0$ (Kadiyala and Karlsson, 1997), which is diagonal with elements σ_i^2, the residual variance of an AR(1) for variable i for $1 \leq i \leq n$. The prior mean and variance for $\boldsymbol{B}$ are characterized by a Minnesota-type prior such that

$$\mathbb{E}[(\boldsymbol{B}_\ell)_{ij}|\boldsymbol{\Sigma}] = \begin{cases} \delta_i, & i = j, \ell = 1 \\ 0, & \text{otherwise} \end{cases}, \mathbb{V}[(\boldsymbol{B}_\ell|\boldsymbol{\Sigma})_{ij}] = \begin{cases} \dfrac{\lambda^2}{\ell^2}, & i = j, \forall \ell \\ \dfrac{\lambda^2}{\ell^2}\dfrac{\sigma_i^2}{\sigma_j^2}, & \text{otherwise}, \forall \ell \end{cases}, \tag{8}$$

where $(\boldsymbol{B}_\ell)_{ij}$ denotes the coefficient of variable j in equation i at lag ℓ for $1 \leq \ell \leq p$. Setting $\delta_i = 1$ for all i reflects the belief that all variables are characterized by a random walk with drift as originally proposed by Litterman (1986). However, for variables believed to feature mean reversion this prior is not suitable. For those I impose a prior belief of white noise by setting $\delta_i = 0$ as in Bańbura et al. (2010). The hyperparameter λ governs the overall tightness of the priors. I follow Giannone et al. (2015) and optimally choose λ by treating it as an additional parameter in the model, in the spirit of hierarchical modelling.

[4] Arias et al. (2021) discuss individual versus joint identification with external instruments, highlighting how the results can differ across the two methods when the instruments lack orthogonality.

3.2 Model Specification

The baseline VAR encompasses the following monthly endogenous variables in $\boldsymbol{y}_t$: (i) the GSCPI index of Benigno et al. (2022), and U.S. macroeconomic and financial variables including (ii) industrial production, (iii) core PCE inflation, (iv) import prices for intermediate goods, (v) intermediate producer price index (PPI), (vi) core PCE goods, (vii) core PCE services, (viii) 1-year inflation expectations, (ix) 5-year inflation expectations, (x) the real effective exchange rate, (xi) the excess bond premium (EBP) of Gilchrist and Zakrajšek (2012), (xii) S&P 500 stock prices, (xiii) the Wu and Xia (2016)'s shadow rate, (xiv) the 1-year Treasury bill rate (1YTB), (xv) the 5-year Treasury bill rate (5YTB), (xvi) the 10-year Treasury bill rate (10YTB), and (xvii) the yield curve slope.

Industrial production is a standard output measure and the core PCE is the preferred inflation measure by the Fed. Import and producer prices for intermediate goods, along with core inflation for goods and services and the real exchange rate, are incorporated to shed light on the transmission of GSC shocks. Inflation expectations are essential for the discussion of the inflation-output trade-offs implied by GSC shocks. The EBP is included following Caldara and Herbst (2019), who highlight its significance in the estimation of monetary policy VARs. The Wu-Xia shadow rate and the Treasury bill rates across various maturities aid in distinguishing between the effects of changes in the federal funds rate versus forward guidance. Finally, the yield curve slope serves as the variable to be instrumented for identifying forward guidance shocks.

All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates and inflation expectations, are expressed as year-on-year percentage changes. The estimation period is delimited by the GSCPI index and spans the period from 1998M1 to 2023M12. More data details and sources are provided in Appendix A. I set $p = 6$ and rely on Bayesian techniques to estimate the model.

3.3 External Instrument

For ease of exposition, I focus on the identification of the GSC shock, as it is the primary shock of interest. Additional details on how I identify two U.S. monetary policy shocks essential for the counterfactual analysis are explained in Section 5.2.

We can think of a negative GSC shock as an adverse event, unrelated to fundamentals, associated with the disruption of the supply provision within the operation of global supply chains (see, e.g., Burriel et al., 2023; Clark and Gordon, 2023). Examples include geopolitical incidents such as wars and terrorist attacks, natural disasters such as earthquakes and hurricanes, or pandemics.

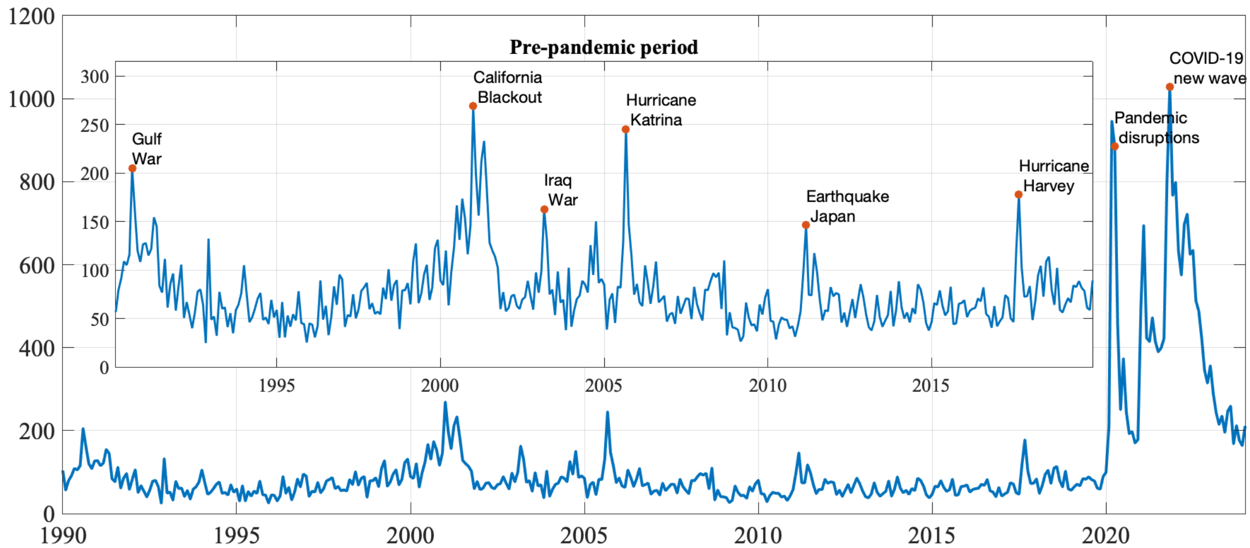
The external instrument z_t^{GSC} for GSC shocks, ε_t^{GSC}, is based on the monthly Supply Bottleneck Index (SBI) for the U.S. economy, developed by Burriel et al. (2023) using newspaper articles.[5] The news-based SBI index, available since 1990 and shown in Figure 2, provides a consistent narrative of both domestic and global supply-side disruptions related to wars, natural disasters, strikes, and the COVID-19 pandemic, making it an ideal indicator to be used as an instrument. Notable global events captured by the SBI index include the Tōhoku earthquake and tsunami in Japan in March 2011, the onset of the COVID-19 pandemic in April 2020, and the new wave of COVID-19 cases in November 2021, which further intensified already widespread supply bottlenecks.

Recent empirical studies have employed (a combination of) these global events to identify GSC shocks using narrative sign restrictions (see e.g. Finck and Tillmann, 2022; Ascari et al., 2023; De Santis, 2023, among others). In this paper, I estimate a single Bayesian VAR to identify a GSC shock and two U.S. monetary policy shocks using external instruments. This approach aims to correctly account for the joint uncertainty in estimating the effects of the three shocks.

Diagnostic checks and instrument validity. Burriel et al. (2023) show that their news-based SBI index does not exhibit a significant correlation with a range of macroeconomic

[5] Burriel et al. (2023) also construct indices for China, France, Germany, Italy, Spain, and the United Kingdom, spanning a much shorter sample.

Figure 2: Supply Bottleneck Index (SBI) for the U.S. economy



Note: SBI index developed by Burriel et al. (2023) based on newspaper articles. The index is normalized to 100 throughout the sample period from 1990M1 to 2023M12.

variables, including oil prices and consumer sentiment.[6] Furthermore, they show that their index is not significantly correlated with the Economic Policy Uncertainty (EPU) index developed by Baker et al. (2016). They show that while war events increase both indices, natural disasters only increase their index. Subsequently, they employ their SBI index as an *internal* instrument and order it first in a recursive VAR (as recommended by Plagborg-Møller and Wolf, 2021), which includes typical US macro data. Their results suggest that a shock of one standard deviation in the SBI index raises both unemployment and prices and decreases industrial production. In contrast, I instrument the GSCPI index with SBI residuals in the Proxy SVAR model.[7]

In Appendix A, I further show that SBI residuals are neither autocorrelated nor significantly correlated with the U.S. monetary policy surprises of Jarociński (2024) and Lewis (2024), which I employ below to identify two U.S. monetary policy shocks. This orthogonality in external instruments justifies considering each of the three shocks (GSC and the

[6]These variables also include stock prices, industrial production, the federal funds rate, consumer prices, producer prices, employment, and the VIX. The authors report a low correlation in the pre-COVID period, which increases somewhat when analysing a post-COVID sample.

[7]The SBI residuals are obtained from an AR(p) regression of the logarithm of the SBI index, where the number of lags is set equal to 12.

two monetary policy shocks) and instruments separately, one at a time, when estimating the Proxy-SVAR model, discussed above.

As previously mentioned, two conditions must be satisfied for the applicability of SBI residuals as an external instrument: relevance and exogeneity. The first condition implies that the instrument is correlated with the true underlying structural shock. While the true structural shock is not directly observed, this condition cannot be tested. However, given that the SBI index is consistent with external narrative information regarding GSC disruptions as documented by Burriel et al. (2023), I assume that z_t^{GSC} is associated with negative GSC shocks, that is, in the relevance condition in equation (4a), we have $\mathbb{E}[z_t^{GSC}\varepsilon_t^{GSC}] \neq 0$. On the other hand, as the instrument is not correlated with other relevant shocks, $\boldsymbol{\varepsilon}_t^{other}$, this allows me to guarantee the exogeneity condition in equation (4b), $\mathbb{E}[z_t^{GSC}\boldsymbol{\varepsilon}_t^{other}] = \mathbf{0}$.

Strength of the instrument. Even if the relevance and exogeneity conditions are met, standard inference in large samples will not yield reliable results when the instrument and the shock are only weakly correlated, as highlighted by Montiel Olea et al. (2021). However, in a fully Bayesian context, such concerns do not compromise the validity of posterior inference, according to Arias et al. (2021). Nonetheless, to rule out weak instrument concerns, it is essential to verify the instrument's strength. This verification can be conducted through an F-test in the first-stage regression of the GSCPI residuals from the VAR on the instrument, ensuring that the F-statistic meets a threshold value of 10 (see Montiel Olea et al., 2021). I find that the first-stage F-statistic is 10.8, indicating that the instrument for GSC shocks is not weak according to this criterion.

4 The Aggregate Effects of GSC Pressure Shocks

This section demonstrates that shocks to global supply chain pressures decrease output and persistently increase core inflation. Delving into the inflationary impact of these shocks, the evidence suggests that increased production costs, potentially passed on to consumers, result in higher prices for goods and services and a deterioration of inflation expectations. In response, I document that the Federal Reserve overlooked initial price increases and even implemented a loose policy, presumably to stabilise output, before adjusting its policy in response to persistent inflation.

4.1 Macroeconomic aggregate responses

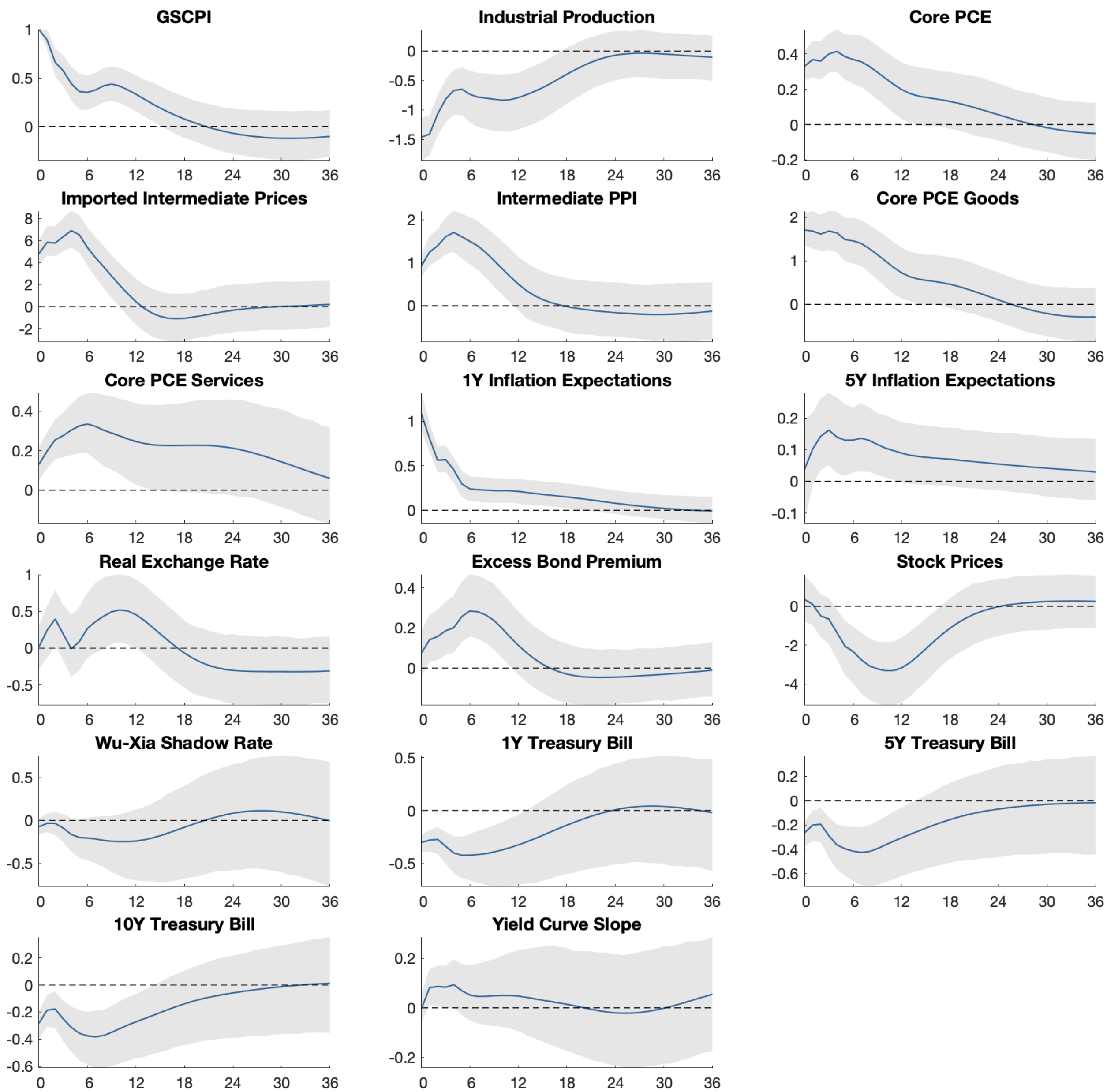
Figure 3 displays the IRFs of U.S. endogenous variables following a GSC pressure shock, normalised to induce a one-standard-deviation increase in the GSCPI index. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. The GSCPI index rises persistently and remains elevated for nearly 18 months. Industrial production contracts by 1.5% upon impact, gradually recovering over 18 months as global supply chain pressures ease. Simultaneously, core inflation rises by 0.3%, gradually building up and peaking after four months, persisting for 18 months. These responses, based on a Proxy SVAR that does not require imposing restrictions on IRFs, are consistent with the empirical evidence collected for the US, as reviewed in Section 2.

To further understand the inflationary impact of GSC pressures, it is instructive to look "under the hood" of the inflation process. Import prices and PPI inflation for intermediate goods react immediately with a 5% and 1% increase, respectively, peaking after four months and remaining elevated for about 18 months. These responses reflect the scarcity of imported intermediate goods and increased production costs. Regarding core inflation for goods and services, the effect on goods steadily declines but persists over 18 months as supply chains recover, while the effect on services, though more limited, remains persistent. Notably, services inflation consistently increases in the first six months post-shock, mirroring the responses of import prices and PPI inflation. The responses of 1-year and 5-year inflation expectations resemble those of core inflation for goods and services, respectively.

These reactions corroborate the theoretical predictions emphasizing the role of *capacity constraints* in affecting output and inflation.[8] Capacity constraints limit the production and supply of goods, leading to output reductions and inflationary pressures. Furthermore, in

[8]Studies focusing on the repercussions of supply chain disturbances on output and inflation include those that consider the amount of spare-labour capacity (Benigno and Eggertsson, 2023), shortages in the goods market (Blanchard and Bernanke, 2023), capacity constraints (Comin et al., 2023), and spare capacity (Bai et al., 2024).

Figure 3: IRFs to a GSC pressure shock



Note: IRFs of US endogenous variables following GSC pressure shock, normalised to induce a one-standard-deviation increase in the GSCPI. The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

Comin et al. (2023)'s model, while capacity constraints result in a rise in goods inflation, they also point to spillovers from goods to services inflation. This occurs as services use goods as inputs, leading to direct inflation spillovers from binding constraints in the goods sector via input-output linkages.

Meanwhile, the real exchange rate gradually appreciates six months after the shock, likely due to an expenditure-switching effect towards domestically produced goods as the relative price of imported goods rises. The evidence documented by Cavallo and Kryvtsov (2023) may lend some support to this rationale. They investigate the inflationary impact of global supply bottlenecks during the pandemic, focusing on the behaviour of imported products across seven countries. By employing a comprehensive micro dataset on product availability and stockouts, they establish that imported products faced higher inflation rates than domestically produced goods. Although this expenditure-switching effect could positively influence domestic output, the overall effect on the latter is overshadowed by the stagnant production caused by global supply chain disruptions.

Heightened import prices, increased production costs, and reduced production capabilities could raise concerns over potentially lower earnings for firms. Indeed, the EBP increases by 0.2% immediately after the shock, while stock prices gradually decline, bottoming out at about a 3% drop nine months after the shock. These movements signal heightened investor concerns about corporate profitability and firms' ability to meet their debt obligations amid disruptions.

4.2 Monetary policy response

In response to the shock, the Fed reduces the policy rate, evidenced by a gradual decline of around 25 basis points in the Wu-Xia shadow rate and mirrored by a 25-basis point decrease in the 1-year Treasury bill rate. The 5-year and 10-year Treasury bill rates adjust by a similar magnitude. This uniform response across Treasury bills of different maturities is also reflected in the yield curve slope, whose response is not significant. The Fed maintains a loose policy stance for over nine months after the shock. This evidence suggests that historically, the Fed has "looked through" the increase in core PCE inflation, as it may have viewed supply chain issues as temporary and expected inflation to self-correct once the pressures eased. Moreover, the monetary stimulus, despite rising inflation, likely aimed to mitigate the economic contraction.

Subsequently, likely in reaction to a persistent rise in core inflation, particularly in the services sector, and a consistent increase in long-term inflation expectations, the Fed ceased its accommodative policy stance and began a tightening cycle. Following this shift in strategy, core inflation reverted to its pre-shock level remaining persistent over 18 months, mildly decelerating the economic recovery. However, the adjustments are more prolonged for services and long-run inflation expectations.

The dynamics of this monetary policy response, which I will refer to as the *baseline* policy response, align with the narrative provided by Reis (2022) to explain the surge in high inflation in 2021-22. The author offers tentative hypotheses for this occurrence. Among these, he emphasizes the challenges in accurately interpreting the nature of GSC shocks in a period of significant uncertainty, resulting in an extended phase of expansionary policy, and the assumption that inflation expectations were well-anchored, suggesting that any inflationary increases would be transient. In addition, he points out that the Fed's new framework, introduced in 2020, might have led to a greater tolerance for higher inflation. I delve into this last point in detail in Section 5.5.

5 The Role of Monetary Policy in the Transmission of GSC shocks

The results documented above illustrate how global supply chain pressures can lead to increased production costs, which are then potentially passed on to consumers. Under the baseline monetary policy response, this results in higher goods and services prices and persistent core inflation. This section examines how these responses would have changed had the Fed adopted two different monetary policy rules that stabilise inflation and minimise a simple dual-mandate loss function. Using Lucas-critique robust counterfactuals put forward by McKay and Wolf (2023), monetary policy would have been more contractionary if the Fed had stabilised inflation at the cost of a mild front-loaded recession. To optimally achieve its dual mandate, the monetary policy stance should have been more accommodating immediately following the shock but much more restrictive in the medium term.

5.1 Structural Policy Counterfactuals

VAR-based policy counterfactuals typically involve introducing unexpected policy shocks every period throughout the entire impulse-response horizon (e.g., Sims and Zha, 2006). However, as demonstrated by McKay and Wolf (2023), henceforth MW, this approach faces challenges such as the Lucas critique and generally falls short of recovering the authentic policy-rule counterfactual. This limitation stems from the assumption that, despite recurrent surprises, agents do not adjust their expectations regarding future policy paths. In essence, this approach overlooks a potential *expectations channel* through which a change in the policy rule might influence the economy.

MW introduce an approach for formulating policy-rule counterfactuals in VAR models that is robust to the Lucas critique and accurately retrieves the true policy-rule counterfactual across a family of structural models, including New Keynesian models. Specifically, they demonstrate that leveraging news shocks about current and future policy captures the impulse responses expected under a counterfactual policy rule.

Environment. MW consider a linear, perfect-foresight, infinite-horizon economy in terms of deviations from the deterministic steady state for periods $t = 0, 1, 2, \ldots$. This economy is separated into two blocks: the non-policy block and the policy block, which are expressed in sequence-space notation as follows:

$$\text{Non-policy block:} \quad \mathcal{H}_x \boldsymbol{x} + \mathcal{H}_z \boldsymbol{z} + \mathcal{H}_\epsilon \boldsymbol{\epsilon} = \boldsymbol{0} \tag{9a}$$

$$\text{Policy block:} \quad \mathcal{A}_x \boldsymbol{x} + \mathcal{A}_z \boldsymbol{z} + \boldsymbol{\nu} = \boldsymbol{0}, \tag{9b}$$

where $\boldsymbol{x} \equiv (\boldsymbol{x}_1', \boldsymbol{x}_2', \ldots, \boldsymbol{x}_{n_x}')'$ stacks the time paths of the n_x endogenous variables, analogously $\boldsymbol{z}$ represents the n_z policy instruments. The linear maps $\{\mathcal{H}_x, \mathcal{H}_z, \mathcal{H}_\epsilon\}$ summarize the behaviour of agents in the non-policy block of the economy, while $\{\mathcal{A}_x, \mathcal{A}_z\}$ describe the *baseline* policy rule of interest. $\boldsymbol{\epsilon}$ denotes the n_ϵ non-policy structural shocks and $\boldsymbol{\nu}$ the n_ν policy shocks. As emphasized by MW, for $t > 0$, policy shocks should be interpreted as *news shocks*—that is, deviations from the policy rule announced at date 0 but implemented at $t > 0$. Bearing this in mind, I will refer to them as policy news shocks.

The fundamental assumption conveyed by equations (9) is that $\{\mathcal{H}_x, \mathcal{H}_z, \mathcal{H}_\epsilon\}$ do not depend on the coefficients of the policy rule $\{\mathcal{A}_x, \mathcal{A}_z\}$. This implies that the impact of policy on the non-policy block's decisions occurs solely through the path of the instrument $\boldsymbol{z}$, rather than directly through the policy rule itself. MW highlight that this assumption remains valid across a general family of structural models.

From policy shocks to rule counterfactuals. Under the assumption that the solution exists and is unique, the solution to equations (9) can be expressed as:

$$\begin{bmatrix} \boldsymbol{x} \\ \boldsymbol{z} \end{bmatrix} = \begin{bmatrix} \boldsymbol{\Theta}_{x,\epsilon,\mathcal{A}} & \boldsymbol{\Theta}_{x,\nu,\mathcal{A}} \\ \boldsymbol{\Theta}_{z,\epsilon,\mathcal{A}} & \boldsymbol{\Theta}_{z,\nu,\mathcal{A}} \end{bmatrix} \times \begin{bmatrix} \boldsymbol{\epsilon} \\ \boldsymbol{\nu} \end{bmatrix} = \boldsymbol{\Theta}_{\mathcal{A}} \times \begin{bmatrix} \boldsymbol{\epsilon} \\ \boldsymbol{\nu} \end{bmatrix} \tag{10}$$

where $\boldsymbol{\Theta}_{\mathcal{A}}$ collects the impulse responses of the non-policy variables $\boldsymbol{x}$ and the policy instrument $\boldsymbol{z}$ under the baseline policy rule summarized by $\mathcal{A}$.

In the counterfactual analysis below, I am interested in examining the impulse responses to a global supply chain disruption shock under alternative monetary policy rules. My objects of interest are the analogous impulse responses if the policy block (9b) was replaced by the counterfactual policy rule

$$\tilde{\mathcal{A}}_x \boldsymbol{x} + \tilde{\mathcal{A}}_z \boldsymbol{z} = \boldsymbol{0}, \tag{11}$$

where $\tilde{\mathcal{A}}_x$ and $\tilde{\mathcal{A}}_z$ represent the coefficients of the counterfactual rule. MW show that having information about the impulse responses $\boldsymbol{\Theta}_{\mathcal{A}}$ under the baseline policy rule is sufficient to predict the impulse responses to the structural shock of interest $\boldsymbol{\epsilon}$—a global supply chain shock in this study—under any counterfactual policy rule. This holds even without complete knowledge of all the structural equations of the model. Specifically, they establish that

$$\begin{aligned} \boldsymbol{x}_{\tilde{\mathcal{A}}}(\boldsymbol{\epsilon}) &= \boldsymbol{\Theta}_{x,\epsilon,\mathcal{A}} \times \boldsymbol{\epsilon} + \boldsymbol{\Theta}_{x,\nu,\mathcal{A}} \times \tilde{\boldsymbol{\nu}}, \\ \boldsymbol{z}_{\tilde{\mathcal{A}}}(\boldsymbol{\epsilon}) &= \boldsymbol{\Theta}_{z,\epsilon,\mathcal{A}} \times \boldsymbol{\epsilon} + \boldsymbol{\Theta}_{z,\nu,\mathcal{A}} \times \tilde{\boldsymbol{\nu}}. \end{aligned} \tag{12}$$

Put differently, the impulse response to the structural shock $\boldsymbol{\epsilon}$ under the counterfactual policy rule is equivalent to a combination of the corresponding impulse responses under the baseline policy rule $\boldsymbol{\Theta}_{x,\epsilon,\mathcal{A}} \times \boldsymbol{\epsilon}$ and the impulse responses to a specific sequence of policy news shocks $\tilde{\boldsymbol{\nu}}$. Intuitively, as long as the decisions of the non-policy block hinge on the path of the policy instrument rather than the policy rule itself, it does not matter whether the path results from the systematic conduct of policy or arises from policy news shocks. Consequently, the policy news shocks $\tilde{\boldsymbol{\nu}}$ are chosen so that the counterfactual policy rule

$$\tilde{\mathcal{A}}_x[\boldsymbol{\Theta}_{x,\epsilon,\mathcal{A}} \times \boldsymbol{\epsilon} + \boldsymbol{\Theta}_{x,\nu,\mathcal{A}} \times \tilde{\boldsymbol{\nu}}] + \tilde{\mathcal{A}}_z[\boldsymbol{\Theta}_{z,\epsilon,\mathcal{A}} \times \boldsymbol{\epsilon} + \boldsymbol{\Theta}_{z,\nu,\mathcal{A}} \times \tilde{\boldsymbol{\nu}}] = \mathbf{0}, \tag{13}$$

holds. A practical challenge in implementing this approach is that policy news shocks $\tilde{\boldsymbol{\nu}}$ which convey changes in future policy across all possible horizons $t, t+1, t+2, \ldots$ are rarely available. However, MW demonstrate that, in practice, we can employ a set of standard monetary policy shocks $\boldsymbol{s}$ and their respective impulse responses $\boldsymbol{\Omega}_{\boldsymbol{s},\mathcal{A}}$ from empirical studies, provided each shock entails a distinct future trajectory for the policy instrument. Furthermore, rather than requiring impulse responses to *as many shocks as horizons* over which the counterfactual policy rule is assumed, using even a limited number of shocks $\boldsymbol{s}$ that minimise

$$\min_{\boldsymbol{s}} \left\| \tilde{\mathcal{A}}_x[\boldsymbol{\Theta}_{x,\epsilon,\mathcal{A}} \times \boldsymbol{\epsilon} + \boldsymbol{\Omega}_{x,s,\mathcal{A}} \times \boldsymbol{s}] + \tilde{\mathcal{A}}_z[\boldsymbol{\Theta}_{z,\epsilon,\mathcal{A}} \times \boldsymbol{\epsilon} + \boldsymbol{\Omega}_{z,s,\mathcal{A}} \times \boldsymbol{s}] \right\|, \tag{14}$$

yields a reliable best *Lucas-critique-robust* approximation, as economic agents' expectations regarding a future policy change are already reflected in the impulse responses to a policy shock path.

5.2 Implementation

I implement policy-rule counterfactuals with $n_s = 2$ distinct U.S. monetary policy shocks, just like MW do in their application. Specifically, in addition to the GSC shock, I identify a conventional monetary policy (CMP) shock and a forward guidance (FG) shock. I briefly describe the identification strategy and the impulse responses and delegate the details to Appendix B.

Identification of monetary policy shocks using external instruments. I identify CMP and FG shocks using the daily monetary policy surprise series of Jarociński (2024), which account for residual endogenous monetary policy components that are due to the central bank's private assessment of the state of the economy. The methodology commences with the observation that asset-price surprises during FOMC announcements exhibit non-Gaussian behaviour characterised by fat tails. In this context, Jarociński (2024) posits that the surprises in n observed financial market variables around m FOMC announcement, collected in the vector $\boldsymbol{y}_m$, are generated by

$$\boldsymbol{y}_m = \boldsymbol{C}\boldsymbol{u}_{j,m}, \quad u_{j,m} \overset{\text{i.i.d.}}{\sim} \mathcal{T}(\nu), \tag{15}$$

where $\boldsymbol{u}_m$ represents n unobserved structural shocks, and $\mathcal{T}(\nu)$ denotes Student's t-distribution with ν degrees of freedom. The author estimates $\boldsymbol{C}$ and ν through maximum likelihood, using surprises within -10min/$+20$min windows around 241 FOMC announcements from June 1991 to June 2019, sourced from the dataset of Gürkaynak et al. (2005) and the update by Gürkaynak et al. (2022). The vector $\boldsymbol{y}_m$ includes the expected federal funds rate after the FOMC announcement, the 2-year and 10-year Treasury yields, and the S&P 500 Blue-Chip stock-market index. Once $\boldsymbol{C}$ is estimated, the implied shocks $\boldsymbol{u}_m$ can be recovered. Because Jarociński (2024)'s approach identifies structural shocks based on statistical rather than economic assumptions, he labels them *ex post* according to the patterns observed in their estimated effects on financial market variables. From this analysis, he identifies four shocks related to conventional monetary policy, forward guidance, large-scale asset purchases (LSAPs), and central bank information (CBI).

Estimation. I construct monthly CMP and FG instruments by summing the daily surprises within each month. In most cases, there is only one surprise per month, so the monthly surprise simply equals the daily one. Likewise, months without FOMC meetings are assigned a zero value. Using the *same* Bayesian VAR model already estimated in the precedent section, for each instrument, I estimate a Proxy-SVAR model. Specifically, the IRFs to the identified CMP and FG shocks are normalised to induce a 10 basis point increase in the Wu-Xia shadow rate and the yield curve slope, respectively. In Section 6, I explore the robustness of my conclusions using other surprise series, specifically those from Lewis (2024).[9]

[9] The first-stage F-statistics are 14.97 and 15.41, respectively. Instrumenting the 1-year and 5-year Treasury bills instead results in F-statistics below 10. The surprise series from Jarociński (2024) and Lewis

The macroeconomic effects of US monetary policy shocks. I briefly comment on the impulse responses to the two monetary policy shocks. A contractionary conventional monetary policy shock raises shorter-horizon interest rates (Figure B.1). Conversely, a contractionary forward guidance shock raises longer-term interest rates (Figure B.2). Both shocks decelerate real activity and consumer prices and tighten financial conditions. To implement the policy-rule counterfactuals, I assume that both shocks occur simultaneously in period t along with the GSC shock, and choose their size to offset the responses of variables of interest as much as possible.

5.3 What if the Fed stabilised inflation?

In this section, I examine the propagation of negative GSC shocks under a scenario where the Fed stabilises core inflation. Consistent with Wolf (2023), I define the counterfactual monetary policy rule as $\boldsymbol{e}_\pi \boldsymbol{x} = \boldsymbol{0}$, where $\boldsymbol{e}_\pi$ is a $1 \times n_x$ vector of zeros with unity at the position of core inflation in $\boldsymbol{x}$. Restricting the counterfactual to periods $t = 0, 1, 2, \ldots, h$, equation (14) becomes

$$\min_{\boldsymbol{s}} \|\boldsymbol{e}_\pi[\boldsymbol{\Theta}_{x,\epsilon,\mathcal{A}} \times \boldsymbol{\epsilon} + \boldsymbol{\Omega}_{x,s,\mathcal{A}} \times \boldsymbol{s}]\| \,, \tag{16}$$

which involves solving a least-squares minimization problem for n_s unknown period-t Fed policy shocks $\mathbf{s}$ in $h+1$ equations.

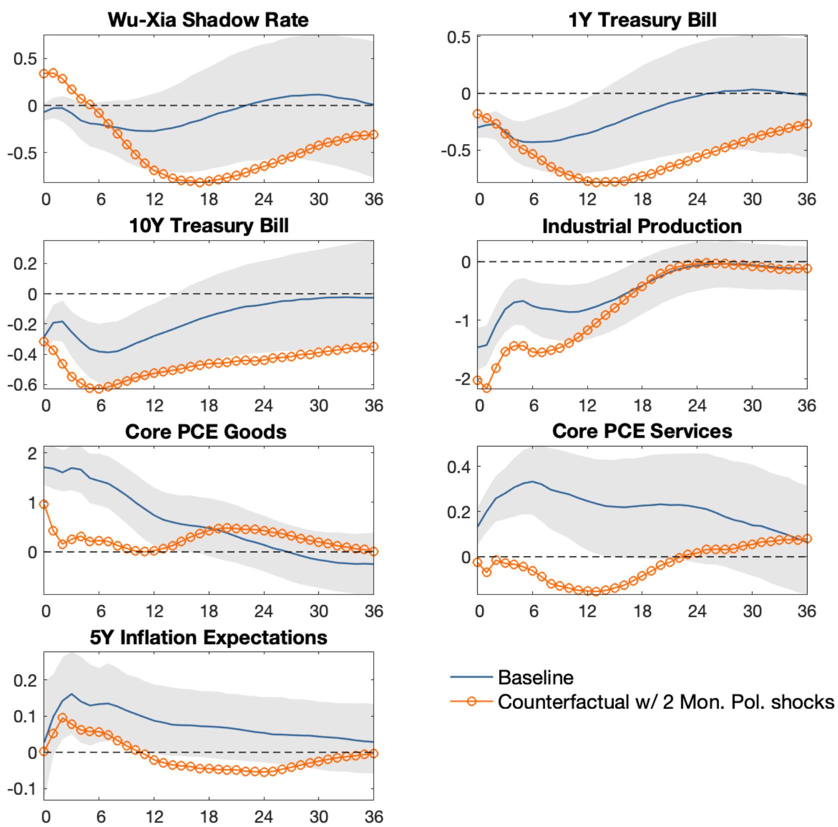
The results of this policy-rule scenario are depicted by the orange circled lines in Figures 4.[10] The evidence indicates that stabilising core inflation would have required a non-trivial tightening, as evident from the immediate response of the Wu-Xia shadow rate to the GSC shock. These estimates imply that a slight but prompt tightening can significantly contribute to stabilising inflation. This policy scenario effectively stabilises both short- and long-term inflation expectations. Nonetheless, the trade-off for this monetary policy tightening, relative to the baseline policy, is a mild recession, further discussed in Section 5.6.

These outcomes further align with theoretical models discussed earlier showing that disruptions to global supply chains appear to enhance the efficacy of contractionary monetary

(2024) are only available from 1991 to 2019. Given that the estimated period spans from 1998 to 2023, I follow prior work in the macro IV literature (e.g., Känzig, 2021) and set the missing values to zero.

[10] For the discussion, I only show the IRFs of interest rates, output, inflation, and inflation expectations.

Figure 4: IRFs to a GSC pressure shock under the baseline policy rule and the counterfactual policy rule that stabilises inflation



Note: IRFs of US endogenous variables following GSC pressure shock under the baseline policy rule (solid lines) and the counterfactual rule (orange circled lines). The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

policy in curbing inflation, while the adverse effects on output remain comparatively reduced. The intuition is that the presence of capacity constraints due to supply chain disruptions means that when the central bank raises interest rates to combat inflation, it does not significantly reduce output, because there is already unutilised productive capacity. Monetary policy is more effective at taming inflation because it does not lead to a substantial drop in economic activity—businesses merely shift from not selling everything they could produce at lower interest rates to not selling everything at higher rates.

5.4 Optimal monetary policy amid GSC disruptions

In Section 5, the evidence shows that the Fed has historically looked through initial price rises following a GSC shock and even implemented a loose policy, presumably to stabilise output, before adjusting its policy in response to persistent inflation. But was this the optimal course of action for a central bank aiming to stabilise both output and inflation? If not, what measures would be necessary to optimally fulfil its dual mandate?

To address these questions, I estimate the effects of a GSC shock under an optimal policy rule corresponding to a loss function with *equal weight* on output and inflation, mirroring the dual mandate of the Federal Reserve. In what follows, I will refer to this rule as the inflation targeting (IT) optimal rule. The advantage of using MW's approach is that I can posit a pertinent loss function instead of deriving it from a welfare maximisation problem tied to a specific model and calibration. I represent such loss function as

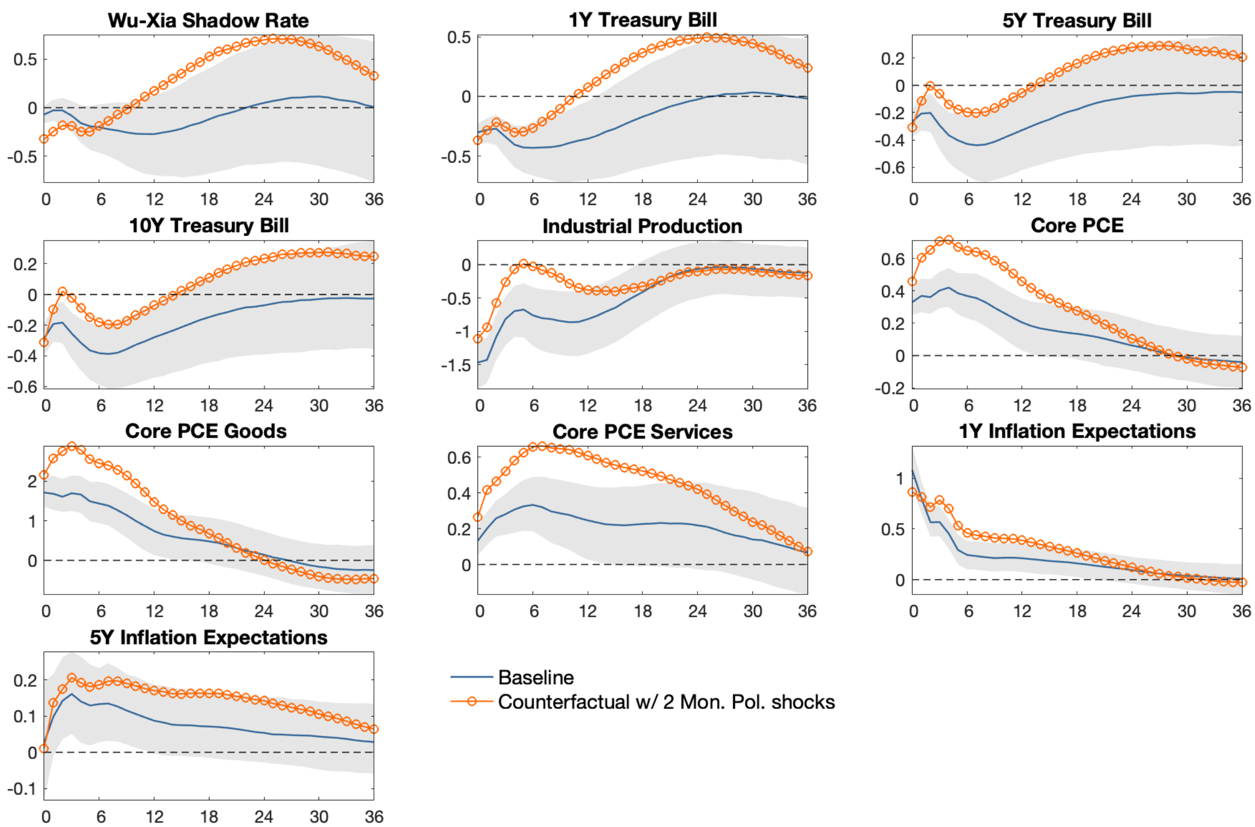
$$\mathcal{L} = \lambda_\pi \boldsymbol{\pi}' W \boldsymbol{\pi} + \lambda_y \boldsymbol{y}' W \boldsymbol{y}, \tag{17}$$

where $\lambda_\pi = \lambda_y = 1$. The discount factor $\beta = 1/1.01$ is set to ensure that, in a standard New Keynesian model, the corresponding annualized interest rate aligns with 2%, roughly the sample average of the Fed's policy rate, and $W = \text{diag}(1, \beta, \beta^2, \ldots)$ allows for discounting. MW obtain the optimal policy rule which is expressed as

$$\lambda_\pi \boldsymbol{\Omega}'_{\pi,s,\mathcal{A}} W \boldsymbol{\pi} + \lambda_y \boldsymbol{\Omega}'_{y,s,\mathcal{A}} W \boldsymbol{y} = \mathbf{0}. \tag{18}$$

The counterfactual responses to this scenario are presented in Figure 5. These results imply that, to fulfil the dual mandate, the policy stance should have been marginally more accommodative in the short term in comparison to the baseline. The additional easing has a somewhat stronger impact on the Wu-Xia shadow rate. It is crucial to note that these estimates do not suggest the Fed should accommodate more than it did to optimally fulfil its mandate. Rather, they indicate that the baseline policy rule is slightly more restrictive relative to this optimal policy. This is indeed reflected in the response of industrial production, where, under the counterfactual, the impact would have been less severe. At the same time, core inflation would have exhibited a more persistent effect, notably in the services

Figure 5: IRFs to a GSC pressure shock under the baseline policy rule and the counterfactual IT optimal policy rule



Note: IRFs of US endogenous variables following GSC pressure shock under the baseline policy rule (solid lines) and the counterfactual rule (orange circled lines). The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

sector. In response, six months later, the Fed would have initiated a period of policy tightening affecting the short end of the yield curve, likely to minimise the risk of expectations de-anchoring. Similarly, these estimates do not endorse an excessive rise in the policy rate by the Fed following a GSC shock to meet its mandate optimally. Instead, it appears that the Fed's response was too accommodative compared to the optimal rule after the GSC shock.

5.5 New Federal Reserve's policy framework

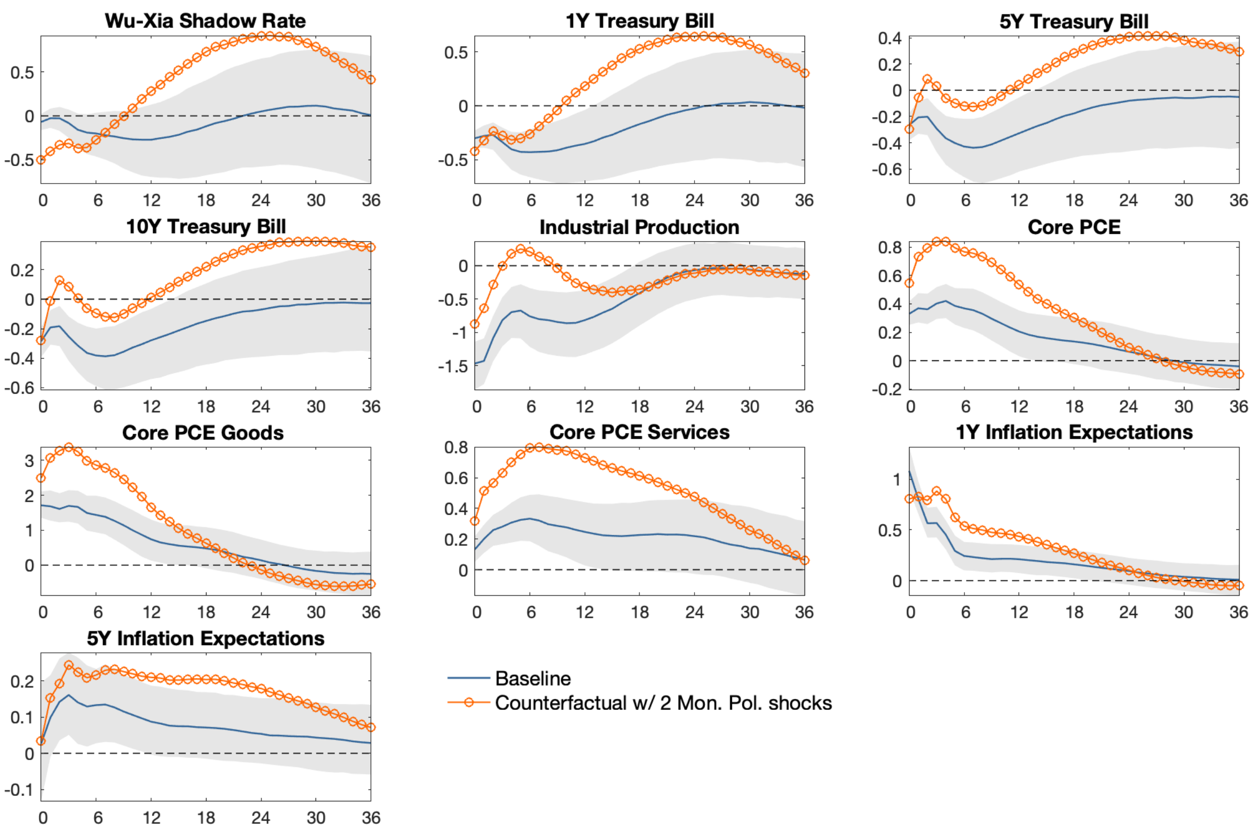
In the spirit of the recent change in the Federal Reserve's long-run policy framework announced in 2020, replacing inflation targeting (IT) with average inflation targeting (AIT) to achieve its dual mandate (see Powell, 2020), I consider a policymaker with preferences over output and average inflation, denoted as $\bar{\pi}_t$, where $\bar{\pi}_t = \sum_{\ell=0}^{L} \omega_\ell \pi_{t-\ell}$. L denotes the maximal (lagged) horizon that enters the inflation averaging, and ω_ℓ denotes the weight on the ℓth lag, with $\sum_\ell \omega_\ell = 1$ and $\omega_\ell \geq 0$ for all ℓ. As pointed out by Jia and Wu (2023), the Fed's communication has been ambiguous about the AIT policy, especially its specific horizon L. For my application, I consider several cases: $L \in \{36, 48, 60\}$ months and $\omega_\ell = 1/L$ (a simple average as in Jia and Wu, 2023) and $\omega_\ell \propto \exp(-0.1 \times \ell)$ (a weighted average as in McKay and Wolf, 2023). Suitably stacking the weights $\{\omega_\ell\}$, we can define a linear map $\bar{\Pi}$ such that $\bar{\boldsymbol{\pi}} = \bar{\Pi} \times \boldsymbol{\pi}$.

I represent the loss function and the optimal policy rule of a dual mandate policymaker with preferences over average inflation respectively as

$$\mathcal{L} = \lambda_\pi \bar{\boldsymbol{\pi}}' W \bar{\boldsymbol{\pi}} + \lambda_y \boldsymbol{y}' W \boldsymbol{y} \quad \text{and} \quad \lambda_\pi \boldsymbol{\Omega}'_{\pi,s,\mathcal{A}} W \bar{\boldsymbol{\pi}} + \lambda_y \boldsymbol{\Omega}'_{y,s,\mathcal{A}} W \boldsymbol{y} = \mathbf{0}, \tag{19}$$

where the parameter values are the same as before. The responses under this optimal rule, with a simple average over a 36-month horizon, are reported in Figure 6. First, I find no significant differences between employing a simple versus a weighted average and $L \in \{36, 48, 60\}$ months. Second, in comparison to the IT-based policy rule, an AIT optimal policy would need an initially looser policy, which eventually leads to higher levels of inflation and inflation expectations. These effects would result in stronger policy tightening, affecting both the short and long end of the yield curve, as observed in the responses of Treasury bills of different maturities. I further comment on these differences based on the implied inflation-output trade-offs in the following section.

Figure 6: IRFs to a GSC pressure shock under the baseline policy rule and the counterfactual AIT optimal policy rule using a simple average over a 36-month horizon



Note: IRFs of US endogenous variables following GSC pressure shock under the baseline policy rule (solid lines) and the counterfactual rule (orange circled lines). The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

Table 1: Ratio of the average median responses of inflation and output

Policy rule	**Baseline**	**Stabilise inflation**	**IT optimal**	**AIT optimal**
Initial policy	Loose	Tight	Loose	Loose
Horizon	$h = 24$			
Core inflation	0.24	0.01	0.45	0.52
Output	-0.69	-1.06	-0.31	-0.21
Trade-off	-0.35	-0.01	-1.44	-2.49
Horizon	$h = 36$			
Core inflation	0.16	0.02	0.31	0.34
Output	-0.48	-0.73	-0.24	-0.17
Trade-off	-0.34	-0.02	-1.29	-2.04

Note: The inflation-output tradeoffs are computed as the ratio of the average responses of inflation and output. "Initial policy" indicates the Fed's reaction to GSC shocks under the respective monetary policy rules.

5.6 The inflation-output trade-offs induced by different policy rules

Table 1 reports the inflation-output tradeoffs by computing the ratio of the average responses of inflation and output across two horizons, either 24 or 36 months after the shock, under the alternative monetary policy rules considered above. Ignoring for the time being the baseline rule and the counterfactual policy rule that stabilises inflation, the ratios range between -1.44 and -2.49 at a 24-month horizon, and between -1.29 and -2.04 at a 36-month horizon. This implies that in the least favourable case (AIT optimal rule), an initial expansionary monetary policy stance causes, over the following 36 months, an average inflation increase of approximately *2.5 times* (in absolute value) the size of the corresponding output reduction. Conversely, under the rule that stabilises inflation, an initial contractionary monetary policy stance proves more effective in controlling inflation without inducing a significant recession (note the 0.48% average reduction under the baseline rule compared to a 0.73% reduction under this counterfactual rule at a 36-month horizon).

On the other hand, the evidence suggests that the AIT optimal rule seems to prioritise output and tolerate higher inflation than the IT optimal rule does. Specifically, under the AIT optimal rule, monetary policy is more accommodative, as noted above, leading to a

0.17% average decrease in output, in contrast to a 0.24% average decline under the IT optimal rule at a 36-month horizon. However, if supply chain disruptions are prolonged and output remains constrained, persistent inflation could begin to unanchor inflation expectations, challenging the Fed's ability to stabilise them later. Such a scenario would require a more aggressive monetary tightening to combat rising inflation than in the IT scenario. This is what we see in the counterfactual responses in Figures 5 and 6. In other words, prices being highly sensitive to GSC disruptions eventually lead to a much more contractionary policy under the AIT optimal rule, worsening the inflation-output trade-off.

In summary, the key insight is that the Fed may not necessarily face an unfavourable trade-off between leaning against inflation and stabilising output. The evidence indicates that stabilising inflation would entail an initially slight tightening, leading to a mild front-loaded recession, but ultimately, ensuring more stable inflation expectations. This result indicates that supply chain-induced inflation can be managed effectively without triggering a significant recession. Moreover, considering the well-documented lags in the transmission of monetary policy, it appears unlikely that any policy rate path could perfectly stabilise the variables of interest in the counterfactuals in the immediate aftermath of the GSC shock. Thus, the empirical analysis employing two monetary policy shocks provides an accurate approximation of the outcomes achievable with an inflation-stabilising policy rule in practice.

6 Robustness

In this section, I show that my results are robust to using alternative instruments to identify U.S. monetary policy shocks and an alternative instrument to identify GSC shocks. All corresponding figures can be found in Appendix C.

Monetary policy shocks identification with alternative instruments. I document that the macroeconomic effects of the CMP and FG shocks, as seen in Figures C.1 and C.2, respectively, are quantitatively similar when using the monetary policy surprises of Lewis (2024), which also control for central bank information effects (the first-stage F-statistics are 18.06 and 15.55, respectively). Using these two shocks in the counterfactual exercises lead to similar conclusions (see Figures C.3 to C.5).

GSC shocks identification with an alternative instrument. I construct an instrument based on events related to global supply chain disruptions, which have been used in the literature as narrative restrictions. Specifically, I include the events identified by Finck and Tillmann (2022) and Ascari et al. (2023): (1) the Tōhoku earthquake and tsunami in Japan in March 2011, (2) the onset of the COVID-19 pandemic in April 2020, (3) the Suez canal obstruction in March 2021, (4) the new wave of COVID-19 cases in November 2021, and (5) the Shanghai backlog in April 2022. The indicator is assigned a value of 1 for each event and 0 otherwise. By design, the instrument meets both the relevance and exogeneity conditions. Concerns regarding a weak instrument are ruled out, as evidenced by an F-statistic of 18.88 in the first-stage regression of the GSCPI residuals from the VAR on the instrument. The IRFs are displayed in Figure C.6. Overall, the responses are qualitatively similar. However, the effects on various inflation measures and inflation expectations are more persistent, while output returns to its pre-shock level relatively more rapidly. Consistent with the baseline analysis, there is further evidence the Fed has historically adopted an accommodative policy in response to the GSC shock, as reflected in the Wu-Xia shadow rate's response.

7 Conclusions

This paper has shown that central banks might not always face unfavourable trade-offs between inflation and output in response to global supply chain shocks. The key explanation for this finding is that prices are significantly more responsive to monetary policy shocks than output during supply chain disruptions. Lucas-critique robust counterfactual analyses suggest that stabilising inflation, albeit at the cost of a mild, front-loaded recession, could potentially yield a more balanced economic outcome in the medium term. In contrast, policy rules that put greater emphasis on output can inadvertently cause more persistent inflation and inflation expectations, thereby exacerbating inflation-output trade-offs.

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A Identification of GSC shocks

A.1 Data

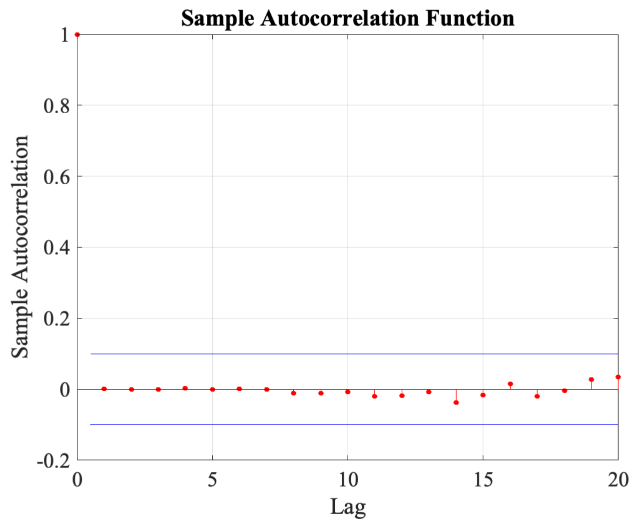
Table A.1: Set of Endogenous Variables

Variable	Description	Source	yoy	RW
GSCPI	Benigno et al. (2022)'s GSCPI index	New York Fed		
Industrial Production	Total Index	FRED	✓	
Core PCE	PCE Excluding Food and Energy	FRED	✓	
Imported interm. prices	Import Price Index: Industrial Supplies and Materials Excluding Petroleum	FRED	✓	
Intermediate PPI	Intermediate materials, supplies, and components	BLS	✓	
Core PCE goods	PCE: Durable Goods	FRED	✓	
Core PCE services	PCE: Excluding Energy and Housing	FRED	✓	
1y inflation exp.	Surveys of Consumers, University of Michigan	FRED	✓	
5y inflation exp.	Surveys of Consumers, University of Michigan (U.M.)	U.M. Website	✓	
Real exchange rate	Real Broad Effective Exchange Rate	FRED	✓	
Excess Bond premium	Gilchrist and Zakrajšek (2012)'s indicator	FED Notes		
Stock Prices	S&P500 Composite Stock Price Index	CRSP	✓	
N-year Treasury bill ($N = 1, 5, 10$)	Treasury Securities at N-Year Constant Maturity	FRED		✓
Yield curve slope	10-Year Treasury Constant Maturity Minus 2-Year Treasury Constant Maturity	FRED		✓

Note: The series are collected from January 1998 to December 2023. The last two columns indicate the transformation of the data to ear-on-year (yoy) percentage changes and whether a random walk (RW) prior was imposed on those variables, respectively.

A.2 Validation Checks

Figure A.1: Autocorrelation Function of SBI residuals



Note: The estimation is based on the median time series of TPU shocks extracted from the SVAR identified with narrative sign restrictions. Sample period 1991M1 to 2023M12.

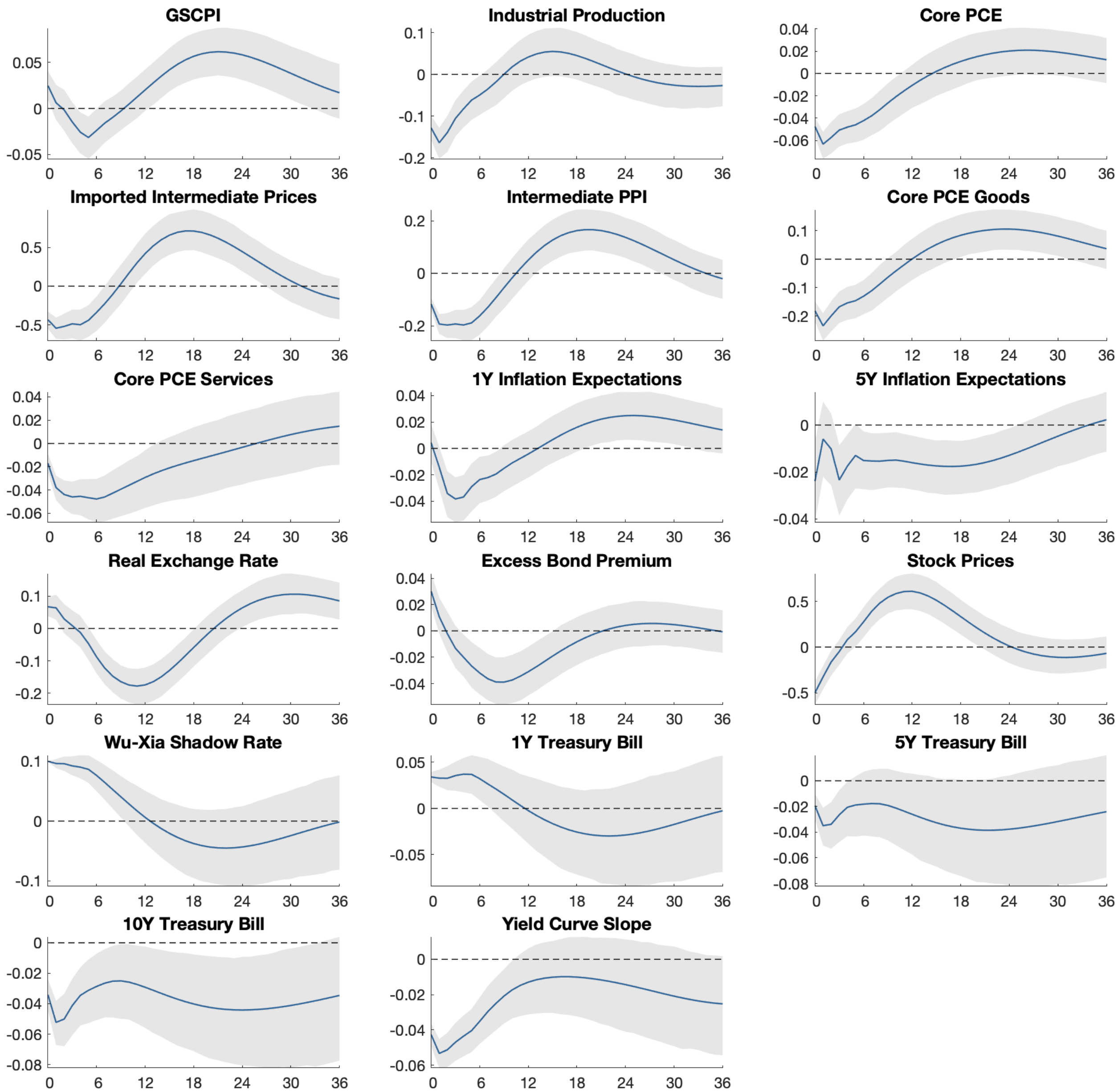
Table A.2: Orthogonality of GSC instrument with U.S. monetary policy surprises

Monetary policy surprise	Correlation (p-value)
Jarociński (2024)'s surprises	
Conventional Monetary policy	0.08 (0.20)
Forward Guidance	0.07 (0.18)
Lewis (2024)'s surprises	
Conventional Monetary policy	0.11 (0.11)
Forward Guidance	0.05 (0.25)

Note: The entries in the table denote the pairwise correlations. The p-values are reported in parentheses. The p-values in the column of correlations correspond to a regression of the SBI residuals on the monetary policy surprise series, computed with the Newey-West HAC estimator. The sample estimation considered is from 1998M1 to 2023M12.

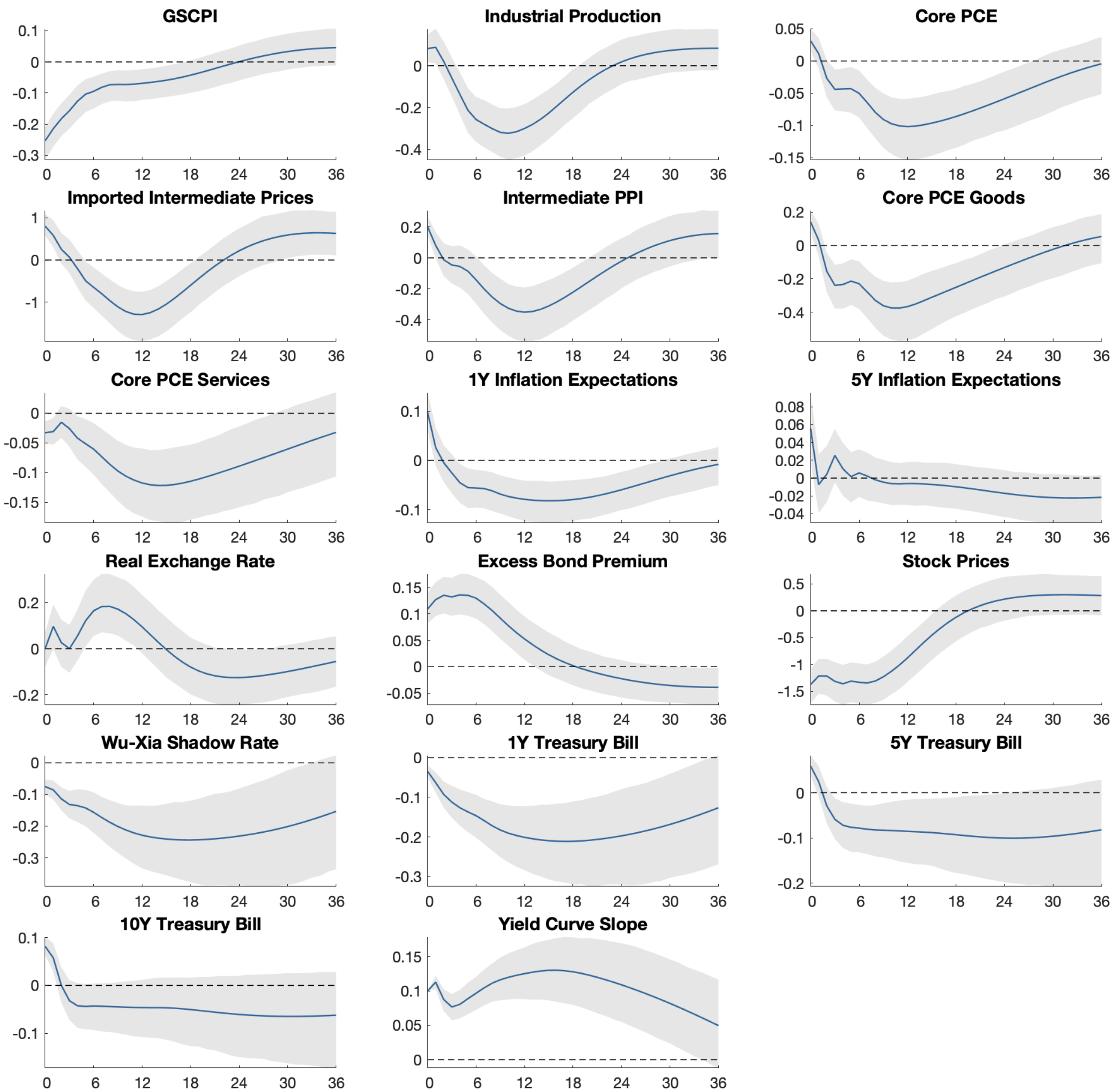
B US monetary policy shocks

Figure B.1: IRFs to a Conventional Monetary Policy (CMP) shock using Jarociński (2024)'s surprise series



Note: IRFs of US endogenous variables following a Conventional Monetary Policy (CMP) shock using Jarociński (2024)'s surprise series as an instrument, normalised to induce a 10 basis point increase in the Wu-Xia shadow rate. The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

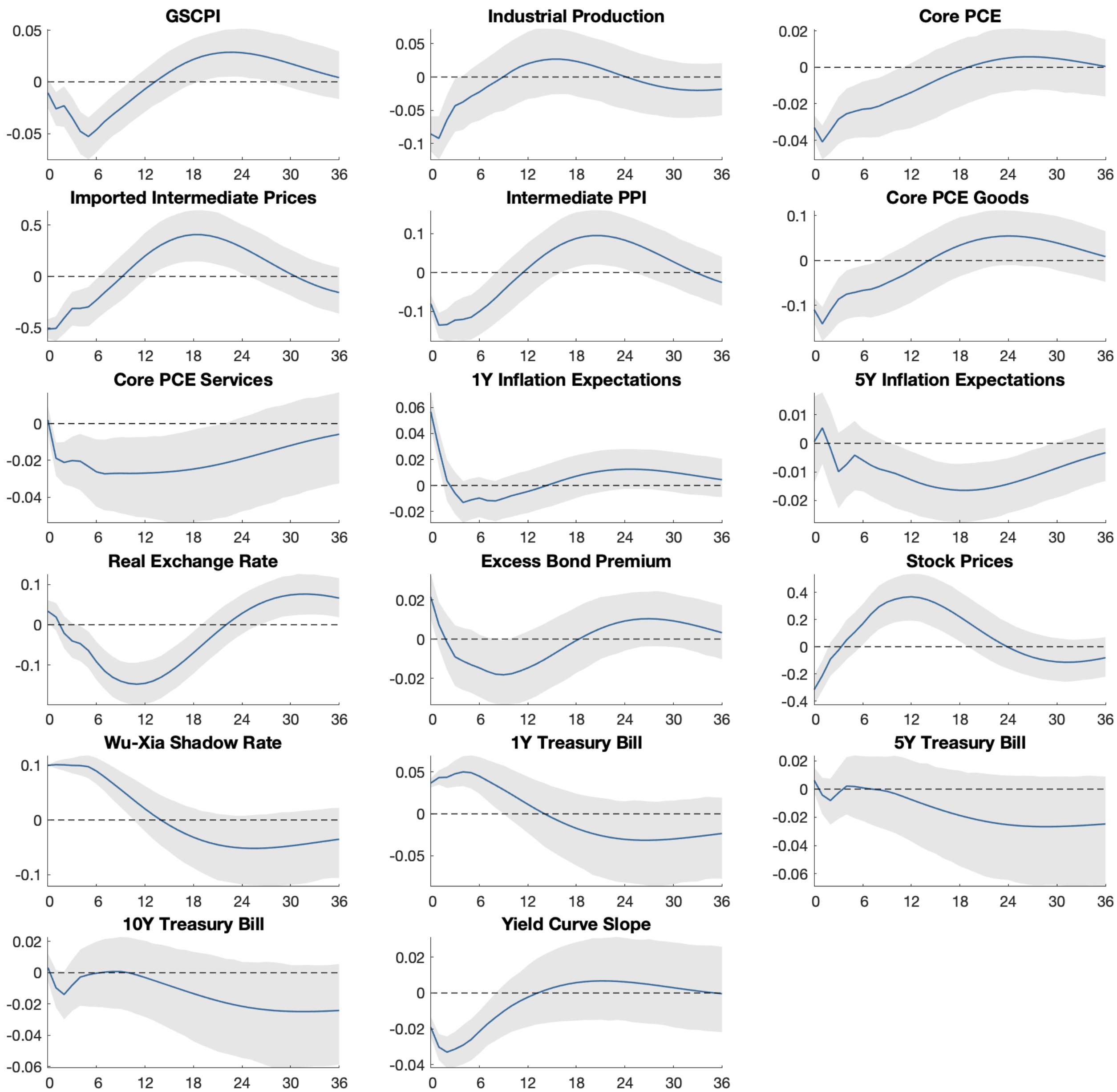
Figure B.2: IRFs to a U.S. Forward Guidance (FG) shock using Jarociński (2024)'s surprise series



Note: IRFs of US endogenous variables following a Forward Guidance (FG) shock using Jarociński (2024)'s surprise series as an instrument, normalised to induce a 10 basis point increase in the yield curve slope. The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

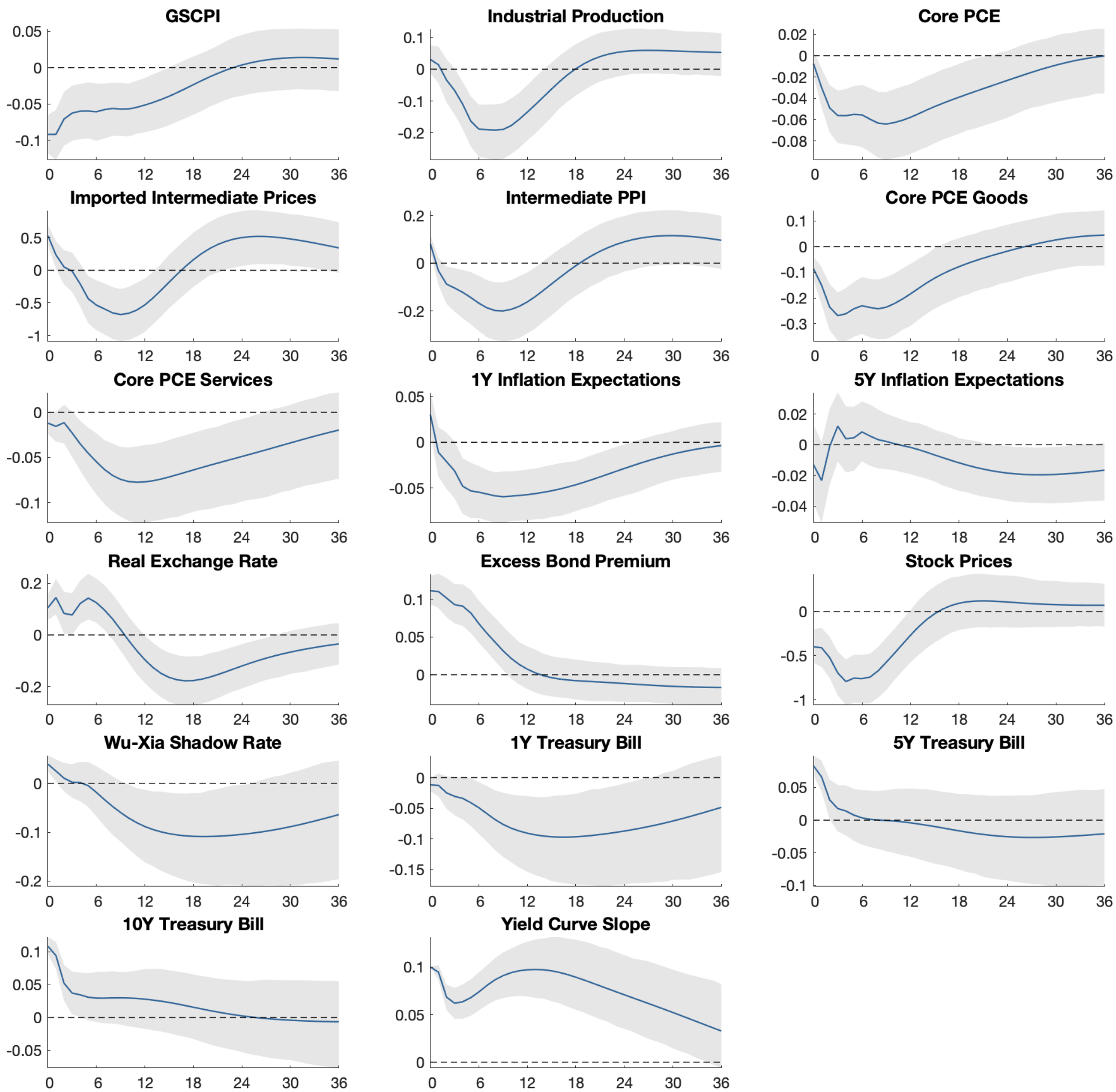
C Robustness

Figure C.1: IRFs to a Conventional Monetary Policy (CMP) shock using Lewis (2024)'s surprise series



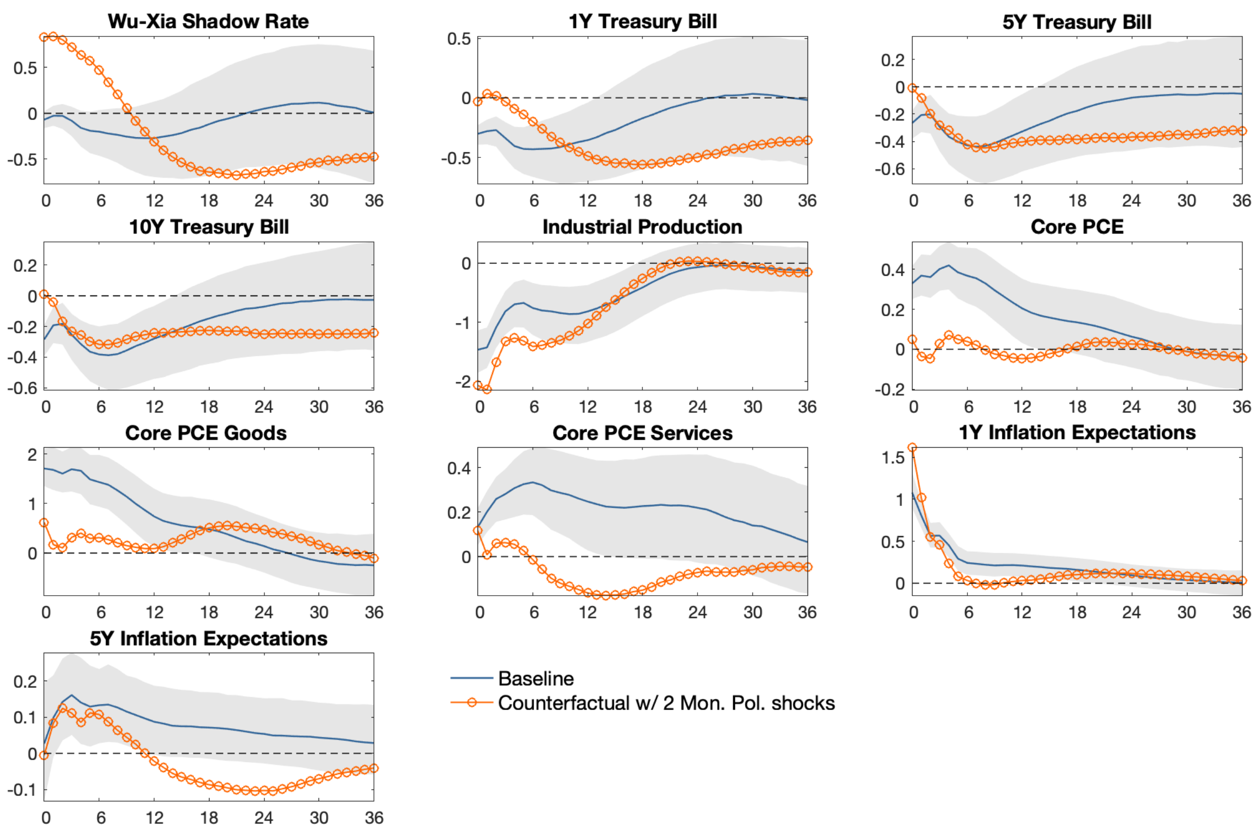
Note: IRFs of US endogenous variables following a Conventional Monetary Policy (CMP) shock using Jarociński (2024)'s surprise series as an instrument, normalised to induce a 10 basis point increase in the Wu-Xia shadow rate. The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

Figure C.2: IRFs to a U.S. Forward Guidance (FG) shock using Lewis (2024)'s surprise series



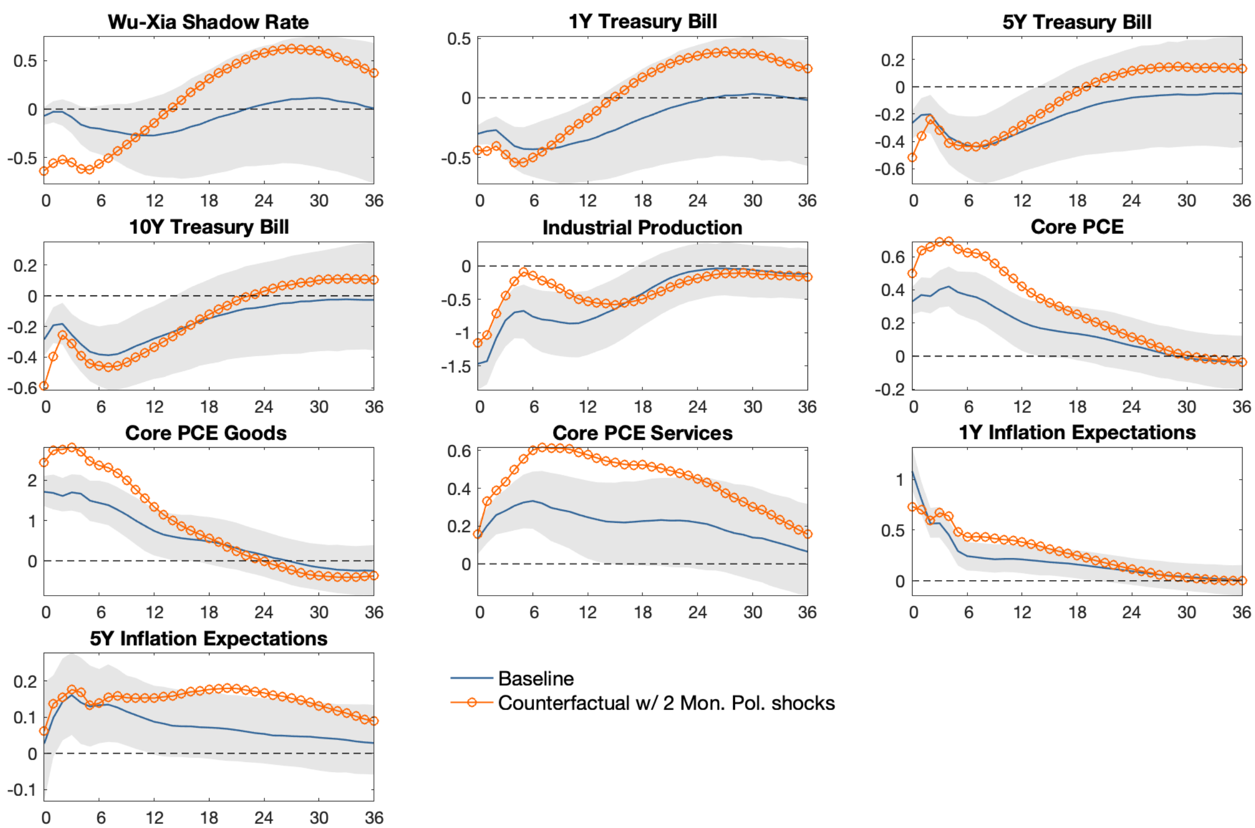
Note: IRFs of US endogenous variables following a Forward Guidance (FG) shock using Jarociński (2024)'s surprise series as an instrument, normalised to induce a 10 basis point increase in the yield curve slope. The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

Figure C.3: IRFs to a GSC pressure shock under the baseline rule and the counterfactual rule that stabilises inflation using Lewis (2024)'s surprise series



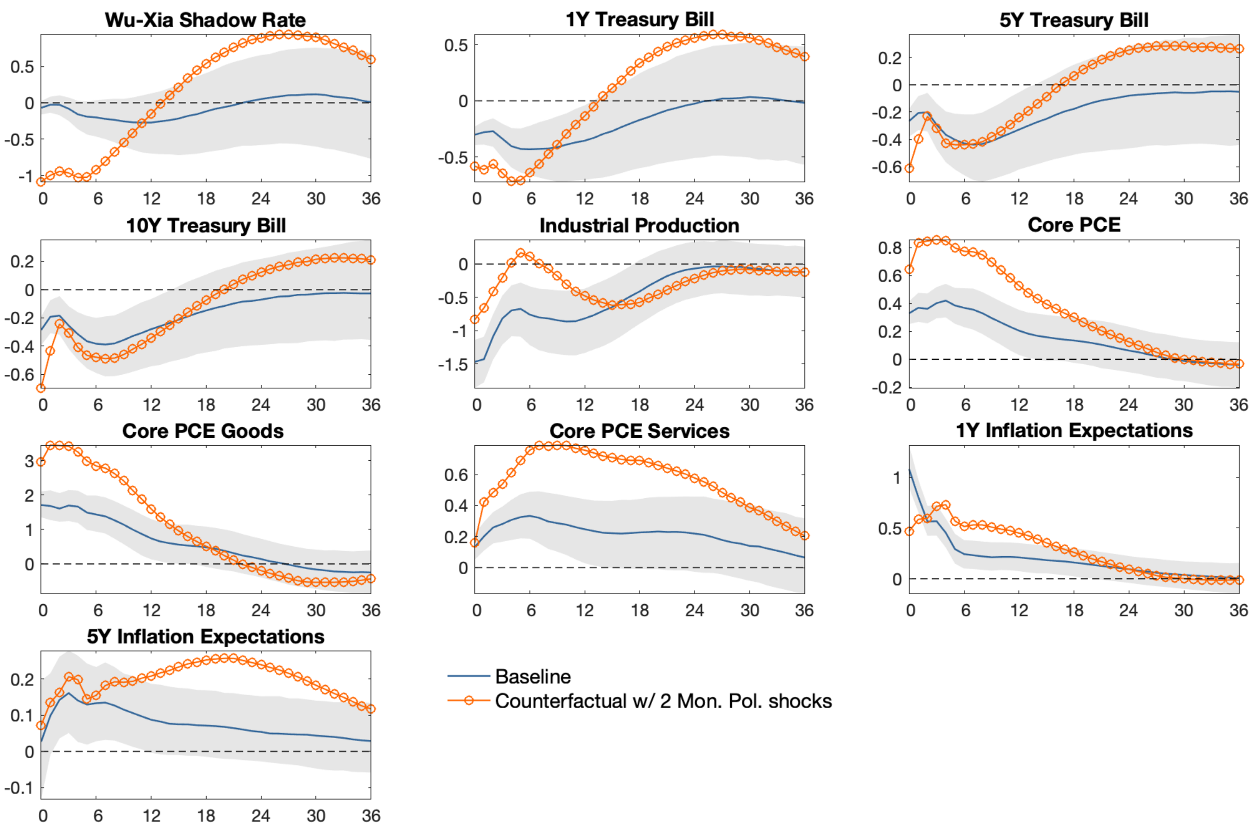
Note: IRFs of US endogenous variables following GSC pressure shock under the baseline policy rule (solid lines) and the counterfactual rule (orange circled lines). The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

Figure C.4: IRFs to a GSC pressure shock under the baseline policy rule and the counterfactual IT optimal policy rule using Lewis (2024)'s surprise series



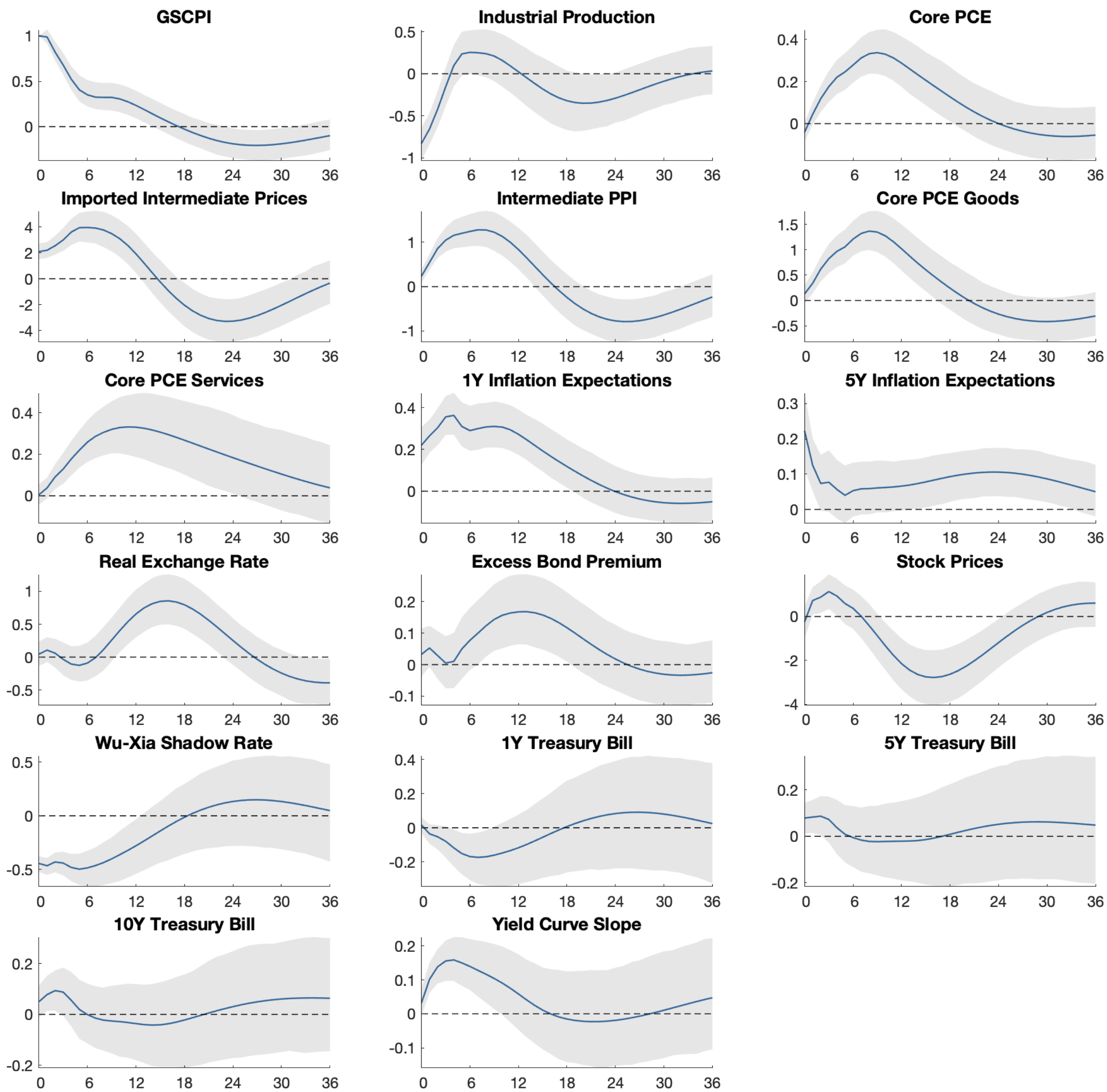
Note: IRFs of US endogenous variables following GSC pressure shock under the baseline policy rule (solid lines) and the counterfactual rule (orange circled lines). The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

Figure C.5: IRFs to a GSC pressure shock under the baseline policy rule and the counterfactual AIT optimal policy rule using Lewis (2024)'s surprise series



Note: IRFs of US endogenous variables following GSC pressure shock under the baseline policy rule (solid lines) and the counterfactual rule (orange circled lines). The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.

Figure C.6: IRFs to a GSC pressure shock using an alternative instrument based on a dummy with five events



Note: IRFs of US endogenous variables following GSC pressure shock, normalised to induce a one-standard-deviation increase in the GSCPI. The horizontal axis measures time in months and the vertical axis deviation from the pre-shock level. The solid lines represent the median response, while shaded areas indicate the 68% posterior coverage bands. All variables, except for the GSCPI index (which is scaled by its standard deviation) and the interest rates, are expressed as year-on-year percentage changes. Estimation sample: 1998M1-2023M12.