Monetary Policy in Emerging Markets under Global Uncertainty

Juan R. Hernández Mateo Hoyos
Daniel Ventosa-Santaulària
Centro de Investigación y Docencia Económicas (CIDE)

August 9, 2024

Abstract

In this paper, we examine the impact of global uncertainty on the effectiveness of monetary policy in reducing inflation in emerging market economies (EMEs). Specifically, we explore the repercussions of: (i) global financial stress; (ii) disruptions in the global supply chain; (iii) heightened levels of global geopolitical uncertainty; and (iv) anomalies attributed to climate change. Our main contribution is to demonstrate that monetary policy in EMEs is effective, albeit to a lesser extent, in reducing inflation when uncertainty is heightened due to global factors. We also find that, among the shocks we study, disruptions in the global supply chain affect the most the policy transmission mechanisms. To identify the monetary policy shocks we use a trilemma-based instrument exploiting surprises in the federal funds rate, and cross section variation in capital account openness of each EME. Our results underscore the complexities inherent in navigating monetary policy within an uncertain global outlook for EMEs.

Keywords: Inflation, Monetary Policy, Emerging Market Economies, Financial Volatility, Global Supply Chain, Policy Uncertainty, Climate Change
J.E.L. Classification Number: C23, C26, C54, E31, E52, F41.
Address for Correspondence: División de Economía. Centro de Investigación y Docencia Económicas. Carretera México-Toluca 3655. Ciudad de México, CP 01210. México.
E-mail: juan.hernandez@cide.edu
mateo.hoyos@cide.edu
daniel.ventosa@cide.edu

1 Introduction

Central banks from emerging market economies (EMEs) have been operating in firefighter mode for several years, responding to a sequence of global shocks. At the same time, these economies face mounting challenges, particularly in maintaining inflation control.

The transmission channels of monetary policy in EMEs is a topic that has drawn a lot of attention. While it has been found that these channels are working as in advanced economies (Checo et al., 2024), some questions remain unanswered. Specifically, in the face of global shocks, which translate into a highly uncertain outlook for an EME, is there a role for domestic monetary policy in stabilizing inflation? Do these shocks affect the effectiveness of monetary policy?

For all the advantages of globalization, there are several examples on how shocks in one economy can rapidly become global. This is, of course, a consequence of financial market integration, the just-in-time production method that requires inputs from around the world, shifts in political direction in countries with significant influence on the demand or supply of commodities, and climate change. All of which call for a reassessment on how markets for goods and assets work.

In this paper, we investigate how global shocks affect the effectiveness of monetary policy in EMEs, particularly in terms of reducing inflation. Specifically, we focus on global shocks that result in heightened uncertainty. We analyze and quantify how global shocks originating from the financial sector, global supply chain, geopolitics and climate change can influence the ability of monetary policy in EMEs to stabilize inflation.

To this end, we use data of 20 EMEs to obtain panel local projections that estimate the response of inflation to changes in the monetary policy rate. Following Jordà et al. (2015, 2020); Stock and Watson (2018), we employ an instrumental variable (IV) approach to identify the monetary policy shocks. More specifically, we use the trilemma-based instrument first proposed by Jordà et al. (2020); Jordà (2023). This instrument consists of unpredictable shocks of the US monetary policy rate (the federal funds rate), scaled by the Chinn and Ito (2006) index to introduce cross-section variation. The index measures the openness of each EME to capital flows. This is how sensitive is the monetary policy of a given economy to shocks in the federal funds rate.

We then estimate state-dependent panel local projections, following the methodology of Cloyne et al. (2023); Gonçalves et al. (2024). This entails including interaction terms between the exogenous monetary policy shocks and the four measures of global shocks. Our results show that the effect of monetary policy on inflation is statistically lower, but different from zero, in contexts where the EMEs are facing high levels of the global shock variables.

Our paper contributes to the growing literature on the identification of monetary policy shocks and its effects in EMEs. Most papers identify a monetary policy shock as the difference between the observed interest rate and a prediction, which can take the form of the fitted value of a Taylor rule (Brandao-Marques et al., 2020), or a median forecast supplied by market participants (Deb et al., 2023; Checo et al., 2024). The identification of monetary policy shocks for EMEs in a panel with high-frequency data from EMEs is still a work in progress. To our knowledge, Checo et al. (2024) is the first attempt in this direction.

Conversely, the trilemma-based IV approach to identify these shocks has already been used for advanced economies in Jordà et al. (2015, 2020); Cloyne et al. (2023) and for an EME in Hernández et al. (2024). Including non-linearities in local projection is still an evolving topic (Auerbach and Gorodnichenko, 2012; Gonçalves et al., 2024; Hernández et al., 2024), but a straightforward method that involves only least-squares estimation is by including interaction terms, as proposed by Cloyne et al. (2023). We use this method and this IV approach, to study state-dependent effects of monetary policy.

Our main finding is that monetary policy in EMEs remains effective in reducing inflation even when uncertainty is heightened due to global factors, but to a lesser extent. In particular, when volatility in the 10-year yield of US Treasuries is relatively high, the response of inflation to a monetary policy shock is lower compared to the benchmark case of relatively low volatility across all horizons. When global supply chain are under stress, the response of inflation to monetary policy shocks is lower, and in even more so after 2 years. When geopolitical risks are heightened, the response of inflation is lower during the first six quarters following the shock. Finally, when there are abnormally high temperatures, the response of inflation to a shock in monetary policy is lower during the initial five quarters. Inflation decreases by less in all cases, but the differences vary, from those in the stressed global supply chain (largest) to those in the higher than average temperatures (smallest).

The remainder of the paper is organized as follows. In Section 2 we describe the global shocks and explain how they may affect the effectiveness of monetary policy in EMEs. We then introduce the empirical approach to obtain our local projections estimates in Section 3. Our findings are discussed in Section 4 followed by a battery of robustness exercises in Section 5. Finally, in Section 6 we outline the policy implications from our work, and outline some concluding remarks.

2 Global Shocks and Uncertainty

In this section, we describe the four variables we use to model global shocks and how each translates to high uncertainty for the policy outlook. We briefly outline how each can affect the channels through which monetary policy affects inflation, based on Mishkin (1995) and BoE (1999). The first of these is the interest rate channel, which operates through an increase in the incentives to save and more costly borrowing terms. When interest rates rise, this channel results in a decreases consumption and investment expenditure, hence leading to lower inflation.

The second channel is associated with the exchange rate, and how its dynamics translate to inflation, particularly of tradable goods. When interest rates rise, or more precisely, when the interest rate differential increases, the exchange rate will appreciate, preventing the prices of imported goods from increasing. This appreciation can also translate into a decrease in aggregate demand through an increase in export prices.

The expectations channel is the third mechanism through which rises in interest rates can affect inflation. In particular, this channel works by signalling that monetary policy is committed to reining in inflation when it accelerates. When inflation expectations are anchored, price setters of domestic goods will consider general price increases as temporary, and will be less inclined to rise prices themselves.

A fourth channel, known as the asset price channel, comes into play when assets on the balance sheet of individuals and firms, both financial and non-financial, lose value due to a rise in the interest rate. This, in turn, represents a constraint on the amount of credit that can be offered or received. The final result is a decrease in total expenditure caused by tighter borrowing constraints, and hence lower inflation.

The credit channel is the fifth channel through which monetary policy can affect inflation. Increases in interest rates can dissuade banks from taking unnecessary risks when lending to firms. Simultaneously, when credit becomes more expensive for firms, they will postpone any plans to increase investment. In both cases, the final outcome is less expenditure and thus, lower inflation.

2.1 Uncertainty from Global Financial Markets

The US 10-year yield Treasury has served as gauge for global financial conditions since the Global Financial Crisis in 2007-2008. As this yield contains expectations of both inflation and interest rates, increases in its volatility can be associated with more frequent outlook revisions by market participants (Cieslak and Povala, 2016). Moreover, given the status of Treasuries as the safest assets in global financial markets, sharp changes of the 10-year yield signal changes in financial conditions.

Since assets in EMEs are relatively riskier than US Treasuries, tighter financial conditions in the US quickly translate to EMEs. The latter pass-through to each economy, in turn, depends on its financial account openness. Among the assets prices that react more rapidly is the exchange rate. This implies that monetary policy would not have the same effect on the exchange rate, as there are other forces determining its dynamics. In other words, the exchange rate channel is impaired, resulting in a diminished effect of monetary policy on inflation.

Figure 1 displays a measure of volatility for the 10-year Treasury yield, provided by the Federal Reserve Bank of St. Louis. We focus on the period 2010-2022 and note that volatility increased in several episodes. First, during the sovereign crisis in the Eurozone in 2011; then during the episode known as the “Temper Tantrum” in 2013; and again during 2015-2016 when the Fed raised the federal funds rate for the first time after the GFC.

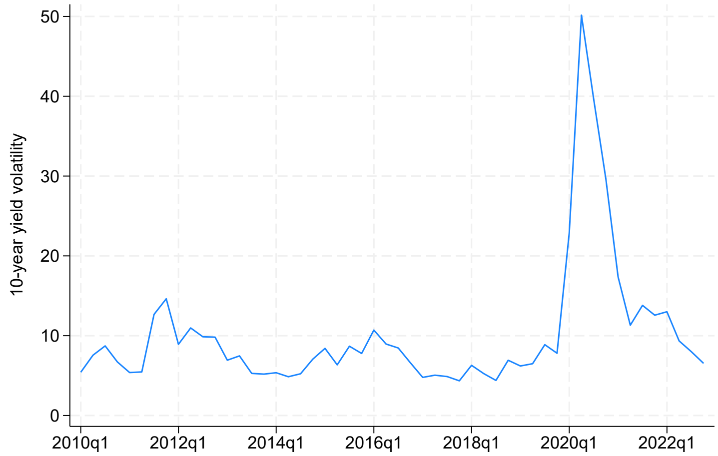

Figure 1: VIX/Market Yield on U.S. Treasury Securities at 10-Year Constant Maturity. Source: FRED.

2.2 Uncertainty from Global Real Shocks

One of the main sources of uncertainty from the real sector of the economy has been the observed shocks to the global supply chain. Globalization and the just-in-time production approach have reduced final goods prices by outsourcing labor and manufacturing to countries that could provide relatively low production costs. However, several events have tested the limits of this approach to production and cost efficiency.

Figure 2 displays the global supply chain pressures index (GSPCI) from Benigno et al. (2022). The GSPCI increased in 2011 after the Tohuku earthquake (which subsequently led to the tsunami in Fukushima) halted the production of microchips. This was followed by the floods in Thailand in 2017 and the trade war between the US and China in 2018. The COVID-19 pandemic introduced additional stress to the global supply chain in early 2020, and the index observed a maximum level in late 2021, amid a full-blown trade war between China and other economies.

Stress on the GSCPI can translate into different inflation dynamics in EMEs, particularly in economies that heavily rely on imports for consumption and where inflation expectations are not anchored. Stress on the GSCPI can also trigger changes in aggregate demand components. If EMEs are receiving more direct investment as a result of supply chain realignments, or if the prices of some goods become more volatile, the effectiveness of the interest rate channel of monetary policy may decrease (Carriére-Swallow et al., 2023). The expectations channel can also be hindered, as inflation becomes more persistent (Fornaro and Wolf, 2023; Hernández et al., 2024).

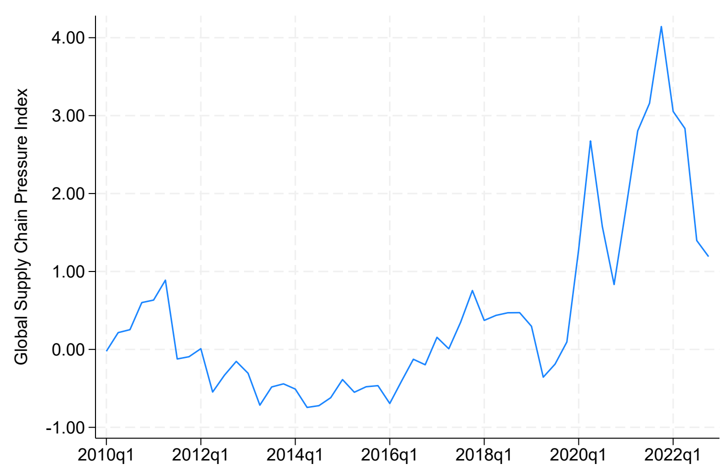

Figure 2: Global Supply Chain Pressure Index. Source: New York FED.

2.3 Global Economic Policy Uncertainty

Global economic policy uncertainty affects monetary policy mainly through the direct interest rate and credit channels (Aastveit et al., 2017). These authors find that consumption and GDP respond less to changes in the interest rate when uncertainty is relatively high. They also find that investment expenditure is considerably less in that context. While the latter can be in line with what we would expect from a rise in interest rates, if income and consumption are not as responsive, the effect on inflation will be smaller. Since the horizon of returns for investment is larger, in a high uncertainty state, the return demanded by financial intermediaries will also be higher.

Figure 3 displays the Global Economic Policy index published by Baker et al. (2022). The index rises during significant geopolitical events, such as the 2018 trade war between the US and China, or more recently, the war between Russia and Ukraine. This index reacts also to political changes, such as elections and economic reforms.[1]

[1] The Global Economic Policy index seems to have an emerging trend. Stationarity is a necessary condition for the econometric analysis described below (Cloyne et al., 2023). Table 1 contains the results from unit-root test. We are able to reject the null hypothesis of the presence of a unit-root.

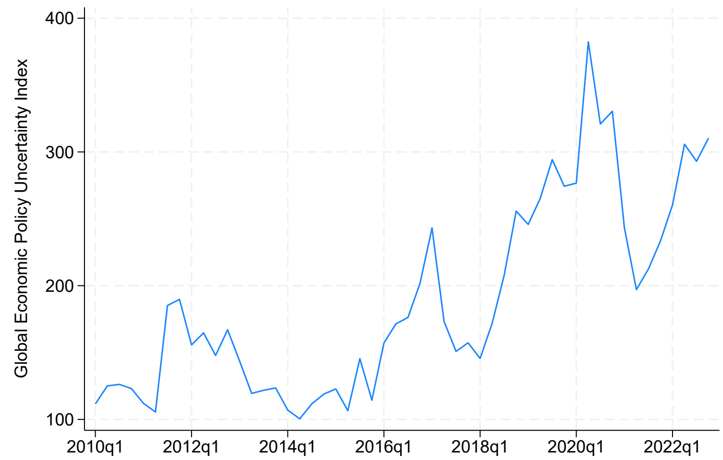

Figure 3: Global Economic Policy Uncertainty Index. Source: The Policy Uncertainty Project.

2.4 Climate Change Uncertainty

Climate change (CC) may significantly impact the conduction of monetary policy and compromise its effectiveness in achieving its goals. CC is associated with an increase in the frequency and severity of extreme weather-related disasters, which can cause substantial supply disruptions and financial instability. In the former case, this can affect global supply chain, reducing the traction and reach of monetary policy (Carriére-Swallow et al., 2023; Hernández et al., 2024). Droughts, heat waves, and floods can drive up commodity and food prices, leading to inflation through agricultural price hikes (see Ventosa-Santaulària et al. (2024), in the context of El Niño - La Niña weather regimes).

CC causes disruptions and losses experienced by both households and firms, particularly in the insurance sector. This can lead to asset stranding and sudden repricing of climate-related financial risks. Such financial stress can disrupt financing flows to the real economy, thereby impairing the transmission of monetary policy through the direct and credit channels. Batten et al. (2016) further argue that policies aimed at reducing pollution and harmful emissions, often result in significant "price adjustments of carbon-intensive assets." As Yusifzada (2023) points out, the increasing frequency of extreme weather events makes it increasingly evident that these events impact the price stability horizon that central banks strive to maintain.

In sum, CC can substantially affect the real economy by hindering production conditions and potentially undermining the stability of the financial system. Both these impacts (on the real and financial sectors) are scenarios where central banks must intervene. We measure one dimension of CC through data on temperature anomalies provided by NASA's GISS Surface Temperature Analysis. Figure 4 shows the combined land-surface air and sea-surface water temperature anomaly, measured as the deviation from the 1951-80 mean in degrees Celsius.[2]

[2] This measure of temperature anomalies displays a trend, but we are able to reject the null hypothesis of the presence of a unit-root. See Table 1.

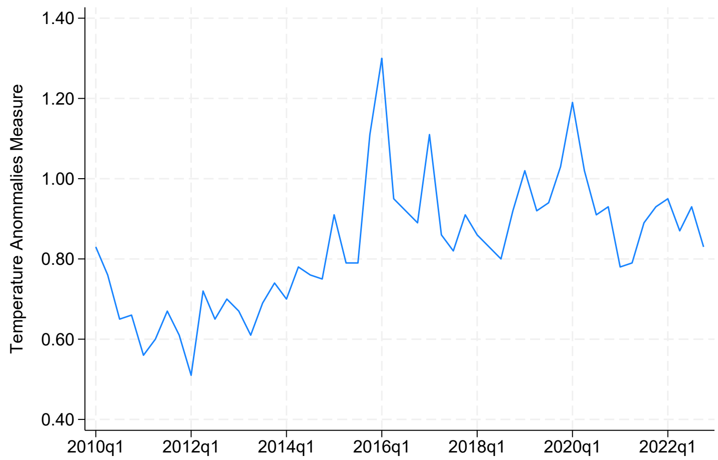

Figure 4: Temperature anomalies. Source: GISS Surface Temperature Analysis (2024). NASA Goddard Institute for Space Studies.

3 Empirical approach

Local projections (LP), as introduced by Jordà (2005), have gained considerable traction in recent empirical research on macroeconomics (Ramey, 2016). Econometric research has demonstrated that impulse responses based on LP, including p lags to address serial correlation, yields results roughly comparable to those derived from a VAR(p) model Plagborg-Møller and Wolf (2021); Li et al. (2024). However, it has also been suggested that LPs might offer advantages for causal analysis. Ramey (2016) and Nakamura and Steinsson (2018) argue that the primary strength of LP over VARs lies in its avoidance of assuming any structure for the data-generating process, particularly concerning the dynamic relationship between shocks and outcomes. As articulated by Li et al. (2024), "empirically relevant DGPs are unlikely to admit finite-order VAR representations, so misspecification of VAR estimators is a valid concern" (p. 31). In addition, the LP estimates offer another advantage: through a straightforward extension, they facilitate the estimation of state-dependent dynamic effects, thereby capturing impulse response heterogeneities (Cloyne et al., 2023; Gonçalves et al., 2024).

In our study, we begin by using LPs to estimate the average dynamic effects of monetary policy on inflation in EMEs. In other words, we are first interested in estimating the cumulative response of consumer price inflation h periods ahead, $y_{i,t+h} - y_{i,t-1}$, to an exogenous monetary policy shock in period t, $\Delta r_{i,t}$. To do so, we control for a set of relevant macroeconomic factors, $\boldsymbol{x}_{i,t}$, which also includes lags of $y_{i,t}$, and for country fixed effects, μ_i^h. The impulse responses are obtained as the estimates for β^h in the following set of linear models, which take the usual long-difference form (Jordà, 2023):

$$y_{i,t+h} - y_{i,t-1} \quad = \quad \Delta r_{i,t} \beta^h + \boldsymbol{x}'_{i,t} \gamma^h + \mu_i^h + \nu_{i,t+h}, \quad h = 0, \ldots 12 \tag{1}$$

where i indexes countries, t indexes quarters, and where the minimum h is 0 and the maximum is 12, meaning we estimate the effect for a three-year window following monetary policy interest rate changes.

We quantify monetary policy interventions with quarterly changes in the target interest rate level decided by the central bank. However, these interventions are influenced by both consumer price inflation and a range of macroeconomic factors. Consequently, directly estimating (1) using ordinary least squares would produce biased estimates of β_h. To address endogeneity concerns, we employ an identification strategy that relies on external instruments.

3.1 Local projections instrumental variables (LP-IV)

Local projections instrumental variables (LP-IV) estimates have by now been extensively used in the literature to identify dynamic causal estimates of macroeconomic shocks (Jordà, Schularick, and Taylor, 2015; Ramey, 2016; Ramey and Zubairy, 2018; Stock and Watson, 2018; Jordà, Schularick, and Taylor, 2020; Jordà, Singh, and Taylor, 2023; Bräuning and Sheremirov, 2023; Hernández, Ventosa-Santaulària, and Valencia, 2024).

In this paper, we particularly follow the identification strategy proposed by Jordà, Schularick, and Taylor (2015, 2020). The authors argue that the "trilemma" of international finance provides a rationale to obtain arguably exogenous variation in interest rates for non-base countries. In a nutshell, a country that pegs its currency to the United States, for instance, loses control over its interest rate, leading to a correlation between the domestic and the US interest rates.

As long as base interest rates are determined fundamentally in relation to this country's domestic economic conditions, the trilemma-induced shifts in the pegging country's interest rates can be treated as exogenous. Importantly for our purposes, in the real world, with frictions and imperfect arbitrage, even for a soft peg or a dirty float exchange rate regime a correlation would exist, as demonstrated both theoretically and empirically by Jordà et al. (2023). In other words, changes in US monetary policy, independent from EMEs conditions, might lead to exogenous changes in interest rates in these countries irrespective of the exchange rate regime.

Our instrument is based on unpredictable movements in interest rates in the US and the capital account openness of each EME. Following Jordà et al. (2020), the idea is that interest rates in EMEs would react to interest rate changes in the US depending on how open they are to capital flows. For instance, if they were totally closed to these flows, there wouldn't be any reason to expect that interest rate changes in the US will lead to changes abroad.

As such, our instrument would be simply the unpredictable changes in US monetary policy weighted by how open the capital account is in each emerging country. In other words, even though changes in US interest rates are arguably unresponsive to EMEs conditions, by using the unpredictable changes we further address potential endogeneity concerns from changes in US economic conditions generated by their economic relations with EMEs.

Formally, we first obtain the unpredictable monetary policy interest rate changes in the US by estimating the residuals from the following regression:

$$\Delta r_t^* \;=\; \alpha^* + \boldsymbol{x}_t^{*'} \gamma_h^* + \eta_t, \tag{2}$$

where Δr_t^* is the first difference of the Fed funds rate and $\boldsymbol{x}_t^*$ are covariates previously used to explain monetary policy decisions (Jordà et al., 2020). More precisely, $\boldsymbol{x}_t^*$ contains two lags of the GDP and two lags of the Consumer Price Index (both in log-difference). Note that, by construction, the estimated Fed policy shocks, $\widehat{\eta}_t$, are orthogonal to economic activity and inflationary pressures in the US.

As mentioned, our instrument not only uses the unpredictable changes in US interest rates, $\widehat{\eta}_t$, but also how open each emerging country is to international capital flows. We particularly use the Chinn and Ito (2006) index, k_{it}, which takes the value 0 if the capital account is completely closed and 1 if completely open. Formally, our trilemma instrument takes the following form:

$$z_{i,t} = \widehat{\eta}_t \cdot k_{i,t} \tag{3}$$

The purpose of using the capital account openness is thus twofold. First, as mentioned, it captures more precisely the rationale behind the trilemma-backed instrument. And second, it allows us to exploit cross-country variation for identification.

Our LP-IV specification entails a first stage regression where changes in EMEs' interest rate are instrumented with the trilemma instrument, as follows:

$$\Delta r_{i,t} = z_{i,t}\psi + \boldsymbol{x}'_{i,t}\delta + \omega_i + u_{i,t} \tag{4}$$

where $x'_{i,t}$ captures EMEs fixed effects and covariates, particularly the first two lags of domestic GDP, CPI and exchange rates (all in log-differences), ω_i refers to country fixed effects, and where ψ captures the first stage coefficient, measuring at the end the relevance of the instrument.

The second stage of our LP-IV specification is essentially the same as equation (1) but using the predicted changes in EMEs' interest rate from the first stage equation (4), $\widehat{\Delta r_{i,t}}$, as follows:

$$y_{i,t+h} - y_{i,t} = \widehat{\Delta r_{i,t}}\beta^h + x'_{i,t}\gamma^h + \mu_i^h + \nu_{i,t+h}, \quad h = 0, \ldots 12 \tag{5}$$

We use bootstrap standard errors clustered (by country) for our LP-IV regressions for several reasons. First, because bootstrapping seems to provide much better inference in finite samples for instrumental variables estimates. Young (2022) recently revisited the empirical settings of more than 1300 instrumental variables regressions published in American Economic Association journals using instrumental variables. The author specifically shows that bootstrapping avoids overconfidence, or type I errors, as compared to robust clustered standard errors.[3]

As mentioned, our standard errors take into account the panel characteristic of our data, so that the resampling of the bootstraps is clustered by country, thus taking into account both heteroskedasticity and autocorrelation at the country level. In short, we use standard errors that are in practice more conservative than robust clustered ones, and that seem to provide better inference according to simulations (Young, 2022).

Second, using bootstrap standard errors also allows us to estimate valid local projections. More specifically, they enable us to use the same first-stage regression coefficient for all time horizons h, thus avoiding potentially large biases in estimates for longer horizons of time (i.e., high h).[4]

[3]More specifically, Young (2022) shows that bootstrap-c methods, although inferior in asymptotic theory, are much more reliable than bootstrap-t alternatives in real-world finite samples. Therefore, we specifically use bootstrap-c standard errors, or the so-called pairs cluster bootstrap-se, in the terminology of Cameron et al. (2008).

[4]To the best of our knowledge, in current empirical practice there is not much of a discussion

We now argue that $z_{i,t}$ is a valid instrument for identification of $\Delta r_{i,t}$, following the conditions discussed by Stock and Watson (2018) and Jordà (2023). Regarding relevance, the first stage coefficient of interest, ψ, is 0.49 with a t-statistic of 4.30 and an F statistic of 20.5, hence statistically different from zero. We further note that the Kleibergen-Paap F statistic, as suggested by Andrews et al. (2019), is 20.1, or that calculated using bootstrapping, as suggested by Young (2022), is 18.5, thus addressing any potential concerns regarding weak instruments inference in our setting.

Regarding contemporaneous exogeneity, we note that unpredictable changes in the federal funds rate are orthogonal to macroeconomic variables in EMEs. It is difficult to argue that consumer inflation in emerging countries is a factor considered by Fed officials in their decision-making process. Moreover, inflation in those countries is not directly linked to US economic conditions, given the unpredictable component we rely on.

Finally, lag-exogeneity is met by including lags of inflation in estimating our impulse responses for each emerging country. Moreover, we included these same lags in the estimates of unpredictable Fed fund rate changes. Lead-exogeneity implies that the instrument is not correlated with future shocks, which is not a restrictive assumption given that the instrument is constructed taking into account only past information (Stock and Watson, 2018).

around this point. By using in-built commands in statistical software programs for instrumental variables regressions, applied researchers usually allow first-stage coefficients to vary with the sample (i.e. to vary with the horizon h where the effects are being estimated) even though the first stage does not depend on h.

3.2 State-dependent LP-IVs

Our main research question concerns the effectiveness of monetary policy under different scenarios of global uncertainties. In other words, our main inquiry is about impulse response heterogeneity due to global shocks. To pursue this type of analysis, we use state-dependent local projections through interaction terms, following closely the formal treatment by Cloyne et al. (2023).[5] These local projections have been widely used in macroeconomic research, especially to estimate fiscal multipliers and monetary policy effects (Ramey and Zubairy, 2018).

The idea behind state-dependent local projections in our setting is simply that monetary policy in EMEs might operate differently in scenarios of high global stress than in scenarios of low global stress. In short, the impulse response functions following exogenous monetary policy shocks may differ depending on the state of a global variable. According to Cloyne et al. (2023), local projections that capture these effect heterogeneities can be simply estimated by carrying out a Kitagawa-Blinder-Oaxaca decomposition, which can be obtained simply by an analysis based on two variables, the shock itself and its interaction with the state variable of interest. Formally, our state-dependent LP-IV estimates are given by the following first- and second-stage regressions:

$$\Delta r_{i,t} = z_{i,t}\psi + \boldsymbol{x}'_{i,t}\delta + s_t\phi + \omega_i + u_{i,t} \tag{6}$$

[5] See Cloyne et al. and references therein on applications of state-dependent local projections. State-dependent local projections have been recently studied in Gonçalves et al. (2024) where they provide a formal treatment on estimation and inference issues on nonlinear state-dependent local projections.

and,

$$y_{i,t+h} - y_{i,t-1} = \widehat{\Delta r_{i,t}}\beta^h + s_t\widehat{\Delta r_{i,t}}\theta^h + s_t\lambda^h + \boldsymbol{x}'_{i,t}\gamma^h + \mu_i^h + \nu_{i,t+h}, \quad h = 0, \ldots 12 \tag{7}$$

where $s_t = \left(S_t - \overline{S}\right)$ is the deviation of S_t from its long-run mean, and S_t represents the global state variables of interest. In our setting S_t will be (i) the volatility observed in the 10-year yield of the US Treasury; (ii) the state of disruption of global value chains; (iii) global economic policy uncertainty; and (iv) temperature anomalies associated with climate change.

There are important differences to note between the state-dependent LP-IV in expressions (6) and (7) and the LP-IV in expressions (4) and (5). First, the state variables, which capture global uncertainties, now appear as a covariate in both the first and the second stages. The importance of controlling for the state variable as a covariate is to avoid potential biases from composition effects, which is why it is common practice in empirical microeconomics settings when the treatment variable is also interacted.

Second, the second stage now has an interaction term, where the exogenous change in interest rates, predicted from the first stage, multiplies the state variable. And third, the state variable appears in both equations centered around the mean, which in turn allows us to separate the effects of monetary policy into direct and indirect effects, following the terminology used by Cloyne et al. (2023).

The direct effect is captured by β^h, and represents the effect of monetary policy for the average level of the state variable, S_t, or when $s_t = 0$. The indirect effect, in turn, is captured by θ^h, and will vary depending on the level of s_t itself. In short, the indirect effect captures how different levels of the state variable change the effect of monetary policy relative to the average.

For example, if S_t stands for global temperature anomalies, the total effect of monetary policy on inflation h quarters after the shock, when the global economy was experiencing two standard deviations more than the long-run average anomaly, is given by $\beta^h + 2 \cdot \theta^h$. We present our state-dependent results below, plotting the impulse responses of monetary policy for situations associated with the 25th (i.e., low stress) and 75th (i.e., high stress) percentiles of each state variable.[6]

Identification of state-dependent local projections generally requires both the shock and the state variable to be exogenous (Cloyne et al., 2023; Gonçalves et al., 2024).[7] As mentioned, identification of monetary policy interest rate changes is based on the trilemma instrument.

Moreover, the state variables that we use represent global shocks causing rises in uncertainty, which are arguably exogenous to domestic conditions of EMEs. It would be difficult to argue that global uncertainties are closely related to domestic conditions of the EMEs we study. Finally, regarding inference, standard errors are obtained through bootstrapping in both stages (clustered by country), thus taking into account the uncertainty from the first stage in the second stage.

[6] For example, the total effect in horizon h for a low stress scenario in temperature anomaly terms is given by $\beta^h - 0.7 \cdot \theta^h$, while that for a high stress scenario is given by $\beta^h + 0.4 \cdot \theta^h$.

[7] Identification of interaction terms has been shown to be less strict. Nizalova and Murtazashvili (2016) show that if the state variable and the omitted source of bias are jointly independent of the exogenous shock, then the OLS estimate of the interaction term is consistent. Similarly, Bun and Harrison (2019) argue that if the reduced form for the shock is linear, OLS identifies the interaction term even if the shock is endogenous.

4 Results

In this section, we present our results. First, we establish the baseline with the impulse-response function (IRF) of a monetary policy shock on accumulated inflation without considering any global variables. Second, we examine the cases with low and high levels of a global state variable, finding that monetary policy is less effective in all four cases - financial, supply, geopolitical, and climatic stress.

It is important to note that while the shocks are exogenous in these four cases, monetary policy still has an effect on inflation, however diminished. We also note that different channels in the transmission to inflation from monetary policy are affected (although there is some overlap), which is why it appears less effective. These disruptions vary in nature and duration, contributing to the diverse impacts on the effectiveness of monetary policy.

Baseline

The baseline response of inflation to a monetary policy shock, without conditioning on any particular global shock, is rather strong. In Figure 5 we show that the accumulated average inflation reaction to a 100 basis point hike in the interest rate is -2.6 percentage points after 4 quarters, -12.7 percentage points after two years, and -22.3 percentage points after 3 years. That said, the reduction in inflation becomes statistically significant only 3 quarters after the policy shock. In other words, monetary policy shocks take a full year to impact inflation. These results align with the existing literature and serve as a benchmark for comparing the following IRFs.[8]

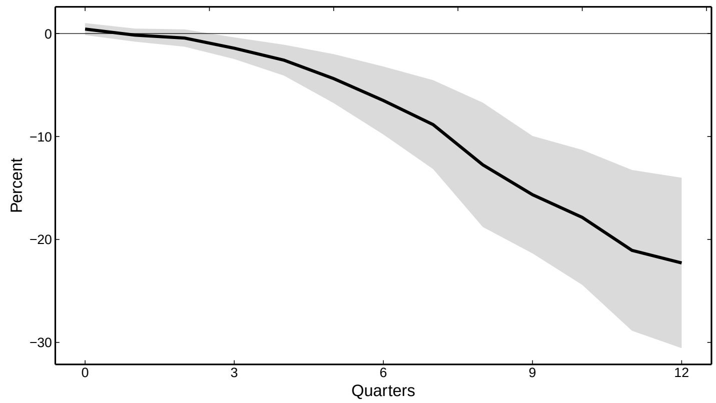

Figure 5: Baseline response of inflation to a 100 basis points increase in the monetary policy interest rate. 90% confidence bands.

Global Financial Uncertainty

The IRFs in Figure 6, right panel, clearly show that there is a non-negligible difference in the impact of interest rate hikes depending on whether global financial uncertainty, measured by the volatility of the US 10-year Treasury yield, is low or high. The accumulated effect is statistically significant in a two-year horizon and the response is smaller -specifically, a 4.1% reduction in the effect on inflation of a 100 basis point increase in the rate after three years. Moreover, under high global financial uncertainty, the impact of monetary policy on inflation takes an additional period to become statistically significant, occurring in the ninth instead of the eighth quarter (Figure 6, left panel).

[8]Although the magnitude of the response seems somewhat stronger than typically found, we note that a monetary policy shock of 100 basis points is large, and that other results (Checo et al., 2024) normalize the response to a benchmark IRF.Therefore, comparisons on the estimated magnitudes are not straightforward.

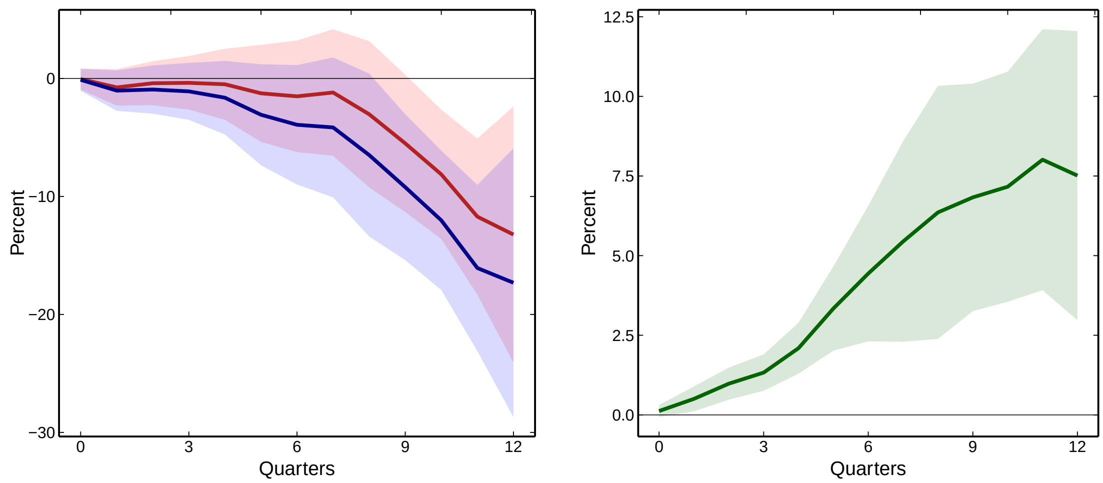

Figure 6: Responses of inflation to a 100 basis points increase in the monetary policy interest rate for different levels of the volatility of the 10-year yield index. Left panel: effects for a low stress scenario, when the economy faces volatility at the the 25th percentile, are shown in blue, and effects for a high stress scenario, when the economy faces volatility at the 75th percentile, shown in red. Right panel: one standard deviation indirect effect of the monetary policy shock in green. 90% confidence bands.

As mentioned above, global financial uncertainty affects the effectiveness of monetary policy mainly through signaling of tighter global financial conditions, which in turn impacts the exchange rate and inflation in the EMEs.

Global Real Sector Uncertainty

IRFs shown in Figure 7 left panel show that, under stress on the global supply chain, the monetary policy in significantly less effective. After two years of the interest rate hike, inflation is reduced by 7.5 percentage points less under stressed global supply chain conditions. The difference increases to 12.7 percent points after 3 years. Note, however, that the lag of the effect of a monetary policy rate hike on inflation remains at eight quarters, regardless of the stress level on the global supply chain (Figure 7 right panel).

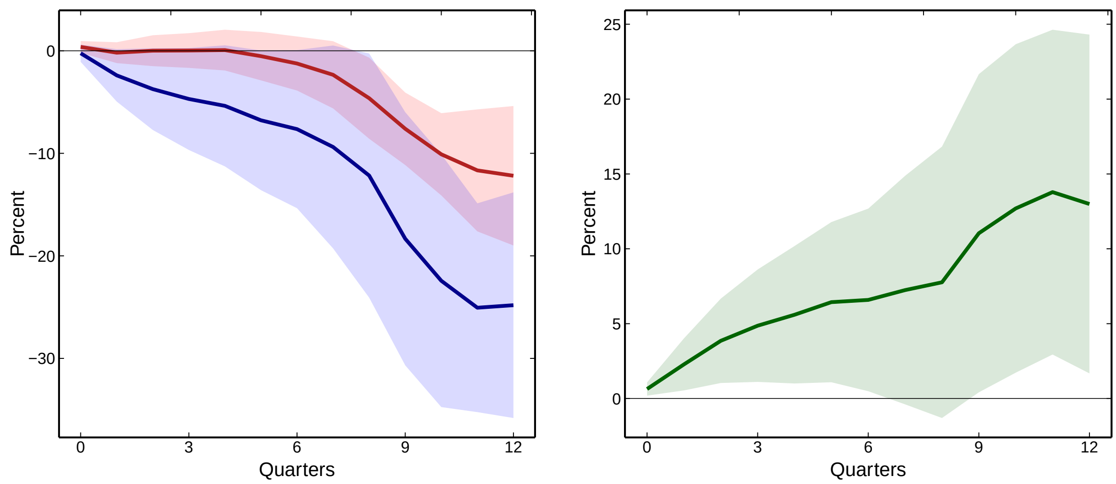

Figure 7: Responses of inflation to a 100 basis points increase in the monetary policy interest rate for different levels of the global supply chain pressure index. Left panel: effects for a low stress scenario, when the economy faces volatility at the the 25th percentile, are shown in blue, and effects for a high stress scenario, when the economy faces volatility at the 75th percentile, shown in red. Right panel: one standard deviation indirect effect of the monetary policy shock in green. 90% confidence bands.

These results provide evidence on how the effectiveness of monetary policy is diminished due to stressed global supply chain (uncertainty from the real sector), presumably through the diminished effect of the interest rate channel (by shifting investment towards EMEs) as well as the expectation channel (due to more persistent inflation).

Global Geopolitical Uncertainty

Global economic policy uncertainty (GEPU), a measure of geopolitical uncertainty, reduces the responsiveness of inflation to interest rate hikes. As depicted in the left panel of Figure 8, inflation is notably less sensitive to monetary policy for almost two years following a rate increase under high global economic policy uncertainty, compared to just one quarter under low global economic policy uncertainty. Under normal conditions, a rate hike impacts inflation almost immediately (in the second quarter), but in a context of high geopolitical uncertainty, its effects are significantly different from zero only after two years.

Moreover, the accumulated effect of an increase in the interest rate under high economic policy uncertainty is substantially smaller than under low economic policy uncertainty: almost 13 percentage points smaller after 3 years. Note that both IRFs are statistically different from the second quarter until the fifth quarter (see the left panel of Figure 8).

This is evidence that geopolitical uncertainty also reduces the impact of monetary policy, presumably by slowing down income, investment, and consumption decisions, thereby diminishing the effectiveness of the interest rate channel, as in the previous case. The effectiveness of the credit channel could also be affected for a similar reason, as banks, facing higher geopolitical uncertainty, reduce lending.

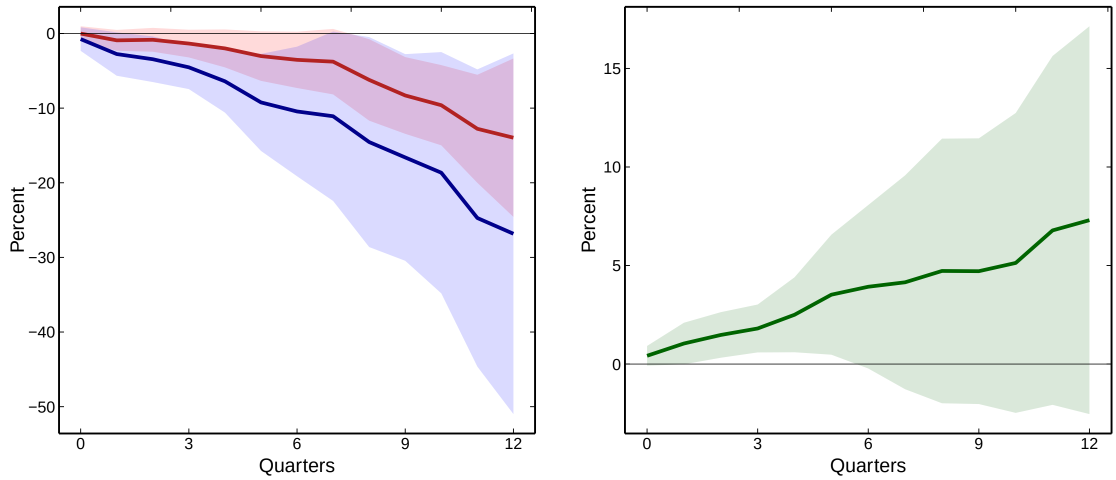

Figure 8: Responses of inflation to a 100 basis points increase in the monetary policy interest rate for different levels of the global economic policy uncertainty index. Left panel: effects for a low stress scenario, when the economy faces volatility at the the 25th percentile, are shown in blue, and effects for a high stress scenario, when the economy faces volatility at the 75th percentile, shown in red. Right panel: one standard deviation indirect effect of the monetary policy shock in green. 90% confidence bands.

Climate Change Uncertainty

We show the IRFs corresponding to higher temperature anomalies in the left panel of Figure 9. The estimates indicate that these anomalies significantly weaken the effectiveness of monetary policy, at least, during the first five quarters after the shock. The response of inflation is statistically indistinguishable from the sixth quarter onward (see the right panel of Figure 9). Specifically, a 100 basis point increase in the interest rate reduces inflation by almost 3 percentage points more after four quarters in the absence of temperature anomalies. However, this difference fades away after three years. This can be summarized as a 2.7 percentage point smaller impact of monetary policy actions during periods of temperature anomalies, only for the first year after the interest rate increase.

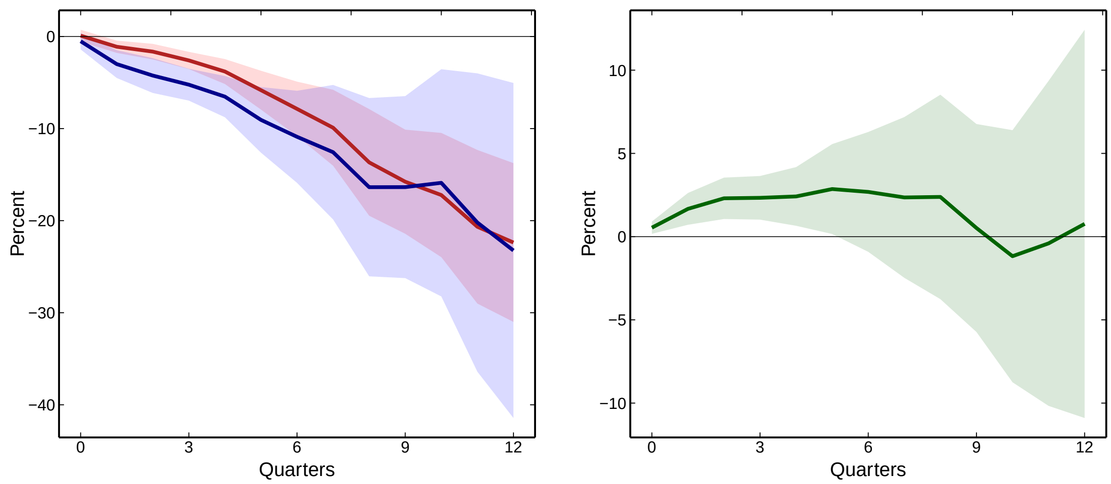

Figure 9: Responses of inflation to a 100 basis points increase in the monetary policy interest rate for different levels of the temperature anomaly measure. Left panel: effects for a low stress scenario, when the economy faces volatility at the the 25th percentile, are shown in blue, and effects for a high stress scenario, when the economy faces volatility at the 75th percentile, shown in red. Right panel: one standard deviation indirect effect of the monetary policy shock in green. 90% confidence bands.

According to these results, temperature anomalies also decrease the impact of monetary shocks on inflation. This may be a consequence of the disruptions in the global supply chain. Increased inflation due to commodity and food price hikes resulting from climatic events is also a key factor. Additionally, the interest rate channel may be hindered by the effects on the insurance sector (again, due to climatic events) and the implementation of pollution reduction policies, further diminishing the effectiveness of monetary policy.

5 Robustness Exercises

We test the robustness of our state-dependent results to alternative lag structures for control variables, changes in the specification to calculate the unpredictable movements in interest rates in the US, and an alternative specification to estimate the state-dependent effects. Reassuringly, all these robustness checks confirm the existence of state-dependent effects of monetary policy based on the level of the global state variables.[9]

First, we check how the results change by changing the number of lags included of control variables in our state-dependent IV estimates, specified in equations (6) and (7). More specifically, we change our main specification based on controlling for two lags of the first difference of (log) GDP, CPI and exchange rate for either including one or three lags. Results are shown in Figures 10 to 17, and they are essentially equivalent to those in the previous section.

Second, we also check the robustness of our results to different specifications to obtain unpredictable changes in monetary policy in the US. In other words, we check how results respond to changes to equation (2). We specifically conduct three changes: controlling for fewer lags of differences in (log) GDP and CPI, controlling for more lags, and adding US inflation expectations one year ahead as an additional control, given that the Fed takes these into account and they potentially capture phenomena different to the variables already included. Results are shown in Figures 18 to 29 and all of them are very similar to those in the previous section.

[9] The Figures displaying results from this Section and further details on the estimation are contained in the Appendix.

Finally, we also conduct a robustness exercise that models state-dependent effects in alternative ways relative to the previous section. As specified in equations (6) and (7), in our main results we first predict the exogenous variation in monetary policy interest rates, and then we use this prediction both as a variable itself and interacted with each state variable in turn in the second stage.

In particular, in the robustness check we estimate two separate first stage regression, one for the interest rate change itself, and another for the interaction term, as specified in equations (8), (9) and (10). In other words, we have a first stage for $\Delta r_{i,t}$, and an additional separate first stage for the interaction term, $s_t \Delta r_{i,t}$, with both predictions then being used separately in the second stage. Results, presented in Figures 30 to 33 are virtually the same as those shown in the previous section, thus confirming our results for the state-dependent monetary policy effects.

6 Policy Implications and Concluding Remarks

In this paper, we set-out to analyze how different global shocks can hinder the effectiveness of monetary policy in fighting inflation. Our identification strategy is based on instrumenting monetary policy changes with unexpected changes in the US federal funds rate scaled by the Chinn and Ito (2006) capital account openness index, the so-called trilemma-based instrument (Jordà et al., 2020). We then combine the instrumental variable approach with state-dependent panel local projections to address our research questions.

Our results suggest that monetary policy in EMEs is indeed less effective in the presence of shocks from the global financial sector, global supply chain, geopolitical developments, or temperature anomalies. All of these are related to increases in uncertainty for the policy outlook, and hinder monetary policy to distinct degrees and horizons. The results also suggest that while shocks are global in nature, monetary policy can still stabilize inflation, but over a longer horizon.

The implications for policy that can be drawn from our analysis are conditional on the source of the global shock. For instance, the central banks in EMEs have an estimate for the required monetary policy response conditional on the source of the global shock. Moreover, monetary authorities can have a time frame with which policy tightening acts on inflation. The latter can be used in a context of monitoring if the transmission channels are working properly.

As ever, this analysis has limitations. There may be other factors that prevent the monetary policy channels from work properly in some EMEs, that are not related to global shocks. Fiscal policy sustainability issues, and individual economic characteristics can also play a role in hindering the effect of monetary policy on inflation. We leave for future research addressing these factors.

Acknowledgements: Mariana Ruiz and Eduardo Valencia provided outstanding research assistance.

Declaration of generative AI in scientific writing: We use the large-scale language model GPT-4 only to improve readability and language.

References

Aastveit, K. A., G. J. Natvik, and S. Sola (2017). Economic uncertainty and the influence of monetary policy. *Journal of International Money and Finance 76*, 50–67.

Andrews, I., J. H. Stock, and L. Sun (2019). Weak instruments in instrumental variables regression: Theory and practice. *Annual Review of Economics 11*, 727–753.

Auerbach, A. J. and Y. Gorodnichenko (2012). Measuring the output responses to fiscal policy. *American Economic Journal: Economic Policy 4*(2), 1–27.

Baker, S. R., N. Bloom, and S. J. Davis (2022). Global economic policy uncertainty index. Available at https://www.policyuncertainty.com/index.html.

Batten, S., R. Sowerbutts, and M. Tanaka (2016). Letâ€™s talk about the weather: the impact of climate change on central banks. Technical report, Bank of England.

Benigno, G., J. Di Giovanni, J. J. Groen, and A. I. Noble (2022). The GSCPI: A new barometer of global supply chain pressures. *FRB of New York Staff Report 1017*, 1–20.

BoE (1999, May). The transmission mechanism of monetary policy. Technical report, Bank of England.

Brandao-Marques, L., G. Gelos, T. Harjes, and Y. Xue (2020). Monetary policy transmission in emerging markets and developing economies. IMF Working Paper 2020/035, International Monetary Fund.

Bräuning, F. and V. Sheremirov (2023). The Transmission Mechanisms of International Business Cycles: International Trade and the Foreign Effects of US Monetary Policy. *IMF Economic Review 71*(1), 300–325.

Bun, M. J. and T. D. Harrison (2019). OLS and IV estimation of regression models including endogenous interaction terms. *Econometric Reviews 38*(7), 814–827.

Cameron, A. C., J. B. Gelbach, and D. L. Miller (2008). Bootstrap-Based Improvements for Inference with Clustered Errors. *The Review of Economics and Statistics 90*(3), 414–427.

Carriére-Swallow, Y., P. Deb, D. Furceri, D. Jiménez, and J. D. Ostry (2023). Shipping costs and inflation. *Journal of International Money and Finance 130*, 102771.

Checo, A., F. Grigoli, and D. Sandri (2024). Monetary policy transmission in emerging markets: Proverbial concerns, novel evidence. Working Paper 1170, Bank for International Settlements. Available at: https://www.bis.org/publ/work1170.htm [Accessed 24-06-2024].

Chinn, M. D. and H. Ito (2006). What matters for financial development? Capital controls, institutions, and interactions. *Journal of Development Economics 81*(1), 163–192.

Cieslak, A. and P. Povala (2016). Information in the term structure of yield curve volatility. *The Journal of Finance 71*(3), 1393–1436.

Cloyne, J., Ò. Jordà, and A. M. Taylor (2023). State-dependent local projections: Understanding impulse response heterogeneity. Working paper, National Bureau of Economic Research, WP #30971.

Deb, P., J. Estefania Flores, M. Firat, and D. Furceri (2023). Monetary policy transmission heterogeneity: Cross-country evidence. IMF Working Paper 2023/204, International Monetary Fund.

Fornaro, L. and M. Wolf (2023). The scars of supply shocks: implications for monetary policy. *Journal of Monetary Economics -*, 1–19.

Gonçalves, S., A. M. Herrera, L. Kilian, and E. Pesavento (2024). State-dependent local projections. *Journal of Econometrics 105702*.

Hernández, J. R., D. Ventosa-Santaulària, and J. E. Valencia (2024). Global supply chain inflationary pressures and monetary policy in mexico. *Emerging Markets Review 58*, 101089.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review 95*(1), 161–182.

Jordà, Ò. (2023). Local Projections for Applied Economics. *Annual Review of Economics 15*(1), 607–631.

Jordà, Ò., M. Schularick, and A. M. Taylor (2015). Betting the house. *Journal of International Economics 96*, S2–S18. 37th Annual NBER International Seminar on Macroeconomics.

Jordà, Ò., M. Schularick, and A. M. Taylor (2020). The effects of quasi-random monetary experiments. *Journal of Monetary Economics 112*, 22–40.

Jordà, Ò., S. R. Singh, and A. M. Taylor (2023). The long-run effects of monetary policy. Working paper, Federal Reserve Bank of San Francisco, WP #2020-01.

Li, D., M. Plagborg-Møller, and C. K. Wolf (2024). Local projections vs. VARs: Lessons from thousands of DGPs. *Journal of Econometrics 105722*.

Mishkin, F. S. (1995, December). Symposium on the monetary transmission mechanism. *Journal of Economic Perspectives 9*(4), 3â€“10.

Nakamura, E. and J. Steinsson (2018). Identification in Macroeconomics. *Journal of Economic Perspectives 32*(3), 59–86.

Nizalova, O. Y. and I. Murtazashvili (2016). Exogenous treatment and endogenous factors: Vanishing of omitted variable bias on the interaction term. *Journal of Econometric Methods 5*(1), 71–77.

Plagborg-Møller, M. and C. K. Wolf (2021). Local projections and VARs estimate the same impulse responses. *Econometrica 89*(2), 955–980.

Ramey, V. (2016). Chapter 2 - Macroeconomic Shocks and their Propagation, Volume 2 of Handbook of Macroeconomics.

Ramey, V. A. and S. Zubairy (2018). Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data. *Journal of Political Economy 126*(2), 850–901.

Stock, J. H. and M. W. Watson (2018, 05). Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments. *The Economic Journal 128*(610), 917–948.

Ventosa-Santaulària, D., E. Tapia, and A. K. Pérez-Peña (2024). Inflation dynamics under different weather regimes: Evidence from mexico. *Ecological Economics 220*, 108179.

Young, A. (2022). Consistency without inference: Instrumental variables in practical application. *European Economic Review 147*, 104112.

Yusifzada, T. (2023). Evaluating the global impact of climate change on agricultural inflation: an innovative climate condition index approach. *Environment, Development and Sustainability*, 1–28.

Appendix A: Unit Root tests

Variable	GSCPI	GEPU	TANO	V10YB
Test statistic	-1.8774	-2.9208	-1.9553	-2.3777
p-value	0.085	0.057	0.07	0.02

Table 1: *note*: Augmented Dickey-Fuller GLS test. Maximum lags according to Schwert's(1989) ad hoc rule, $[12(T/100)^{1/4}]$. Lag selection, Modified BIC (Ng & Perron, 2001) using Perron & Qu (2007) methodology. Constant term included for all variables (GEPU also includes a deterministic trend).

Appendix A Appendix B: IRFs

This appendix provides the numerical data used to build the Impulse Response Functions (IRFs) presented in the figures 5 - 9. The data is organized into five tables, each corresponding to a specific figure and the respective economic variable or indicator analyzed in the main text.

The first table contains the general average effects, illustrating the overall impact of the analyzed variables. The second table details the IRFs under low-/highly stressed global supply chain. The third table presents IRFS under low/high volatility in the 10-year bond yields. The fourth table focuses on the Global Economic Policy Uncertainty (GEPU) index. Finally, the fifth table examines IRFs under low and high temperature anomalies.

Each table is structured to present the estimated beta coefficients and the corresponding 90% confidence interval limits for:

1. the average indirect effect: columns 2-4.
2. the low regime: columns 5-6.
3. the high regime: columns 7-9.

This detailed numerical data serves as the foundation for the graphical representations of the IRFs, ensuring transparency and reproducibility of the analysis conducted in this study.

quarter	β	90% Confidence interval	
		Superior limit	Inferior limit
0	0.43	1.02	-0.15
1	-0.15	0.48	-0.79
2	-0.44	0.40	-1.28
3	-1.43	-0.37	-2.48
4	-2.59	-1.09	-4.09
5	-4.38	-2.00	-6.76
6	-6.51	-3.20	-9.81
7	-8.85	-4.53	-13.17
8	-12.75	-6.71	-18.79
9	-15.65	-9.95	-21.36
10	-17.86	-11.30	-24.41
11	-21.06	-13.25	-28.87
12	-22.28	-14.00	-30.56

Table 2: IRFs: General average effect.

quarter h	θ^h	Average indirect effect 90% Confidence interval Superior limit	Inferior limit	Low regime β^h	90% Confidence interval Superior limit	Inferior limit	High regime β^h	90% Confidence interval Superior limit	Inferior limit
0	0.64	1.08	0.19	-0.24	0.61	-1.08	0.38	0.95	-0.20
1	2.28	4.02	0.54	-2.40	0.16	-4.95	-0.18	0.83	-1.20
2	3.86	6.67	1.04	-3.74	0.25	-7.72	0.01	1.52	-1.50
3	4.86	8.62	1.11	-4.70	0.27	-9.67	0.03	1.72	-1.67
4	5.60	10.19	1.00	-5.37	0.54	-11.28	0.07	2.05	-1.92
5	6.44	11.79	1.09	-6.78	0.04	-13.59	-0.52	1.84	-2.88
6	6.59	12.69	0.49	-7.64	0.07	-15.35	-1.24	1.40	-3.88
7	7.24	14.88	-0.39	-9.38	0.52	-19.28	-2.34	0.94	-5.62
8	7.76	16.83	-1.30	-12.17	-0.26	-24.07	-4.62	-0.67	-8.58
9	11.04	21.67	0.41	-18.33	-5.99	-30.68	-7.61	-4.07	-11.14
10	12.70	23.67	1.73	-22.43	-10.11	-34.75	-10.09	-6.08	-14.11
11	13.79	24.63	2.94	-25.06	-14.88	-35.24	-11.66	-5.71	-17.61
12	12.99	24.31	1.68	-24.81	-13.81	-35.81	-12.19	-5.38	-18.99

Table 3: IRFs: Global supply chain stress.

quarter h	θ^h	Average indirect effect 90% Confidence interval Superior limit	Inferior limit	Low regime β^h	90% Confidence interval Superior limit	Inferior limit	High regime β^h	90% Confidence interval Superior limit	Inferior limit
0	0.12	0.31	-0.07	-0.12	0.81	-1.04	-0.05	0.84	-0.94
1	0.50	0.89	0.11	-1.03	0.69	-2.75	-0.76	0.79	-2.30
2	0.98	1.48	0.48	-0.94	1.11	-2.99	-0.41	1.46	-2.27
3	1.33	1.90	0.76	-1.09	1.32	-3.51	-0.37	1.90	-2.64
4	2.10	2.90	1.29	-1.63	1.49	-4.75	-0.49	2.52	-3.51
5	3.34	4.66	2.02	-3.08	1.21	-7.36	-1.26	2.85	-5.37
6	4.44	6.57	2.31	-3.93	1.13	-8.99	-1.52	3.22	-6.25
7	5.44	8.59	2.30	-4.15	1.78	-10.08	-1.19	4.17	-6.56
8	6.36	10.33	2.39	-6.49	0.41	-13.40	-3.04	3.17	-9.24
9	6.83	10.40	3.26	-9.22	-3.03	-15.40	-5.50	0.32	-11.32
10	7.16	10.78	3.55	-12.02	-6.12	-17.93	-8.13	-2.65	-13.61
11	8.01	12.11	3.92	-16.07	-9.02	-23.11	-11.71	-5.09	-18.33
12	7.51	12.05	2.98	-17.32	-5.93	-28.70	-13.23	-2.38	-24.09

Table 4: IRFs: Volatility in 10-Y Bond.

quarter h	θ^h	Average indirect effect 90% Confidence interval Superior limit	Inferior limit	Low regime β^h	90% Confidence interval Superior limit	Inferior limit	High regime β^h	90% Confidence interval Superior limit	Inferior limit
0	0.42	0.92	-0.08	-0.75	0.83	-2.33	-0.01	0.98	-0.99
1	1.04	2.10	-0.01	-2.75	0.16	-5.66	-0.92	0.49	-2.32
2	1.48	2.63	0.32	-3.45	-0.38	-6.51	-0.84	0.76	-2.44
3	1.81	3.02	0.59	-4.53	-1.61	-7.45	-1.35	0.51	-3.21
4	2.50	4.40	0.60	-6.40	-2.21	-10.60	-2.00	0.55	-4.54
5	3.52	6.57	0.47	-9.23	-2.73	-15.74	-3.03	0.30	-6.35
6	3.92	8.07	-0.23	-10.45	-1.76	-19.13	-3.53	0.24	-7.31
7	4.15	9.58	-1.28	-11.09	0.27	-22.44	-3.77	0.62	-8.16
8	4.72	11.44	-1.99	-14.54	-0.47	-28.62	-6.22	-0.76	-11.68
9	4.71	11.46	-2.03	-16.61	-2.76	-30.46	-8.30	-3.16	-13.45
10	5.13	12.74	-2.48	-18.65	-2.49	-34.82	-9.61	-4.23	-14.99
11	6.78	15.63	-2.07	-24.72	-4.81	-44.64	-12.77	-5.53	-20.01
12	7.30	17.14	-2.54	-26.83	-2.67	-51.00	-13.96	-3.34	-24.58

Table 5: IRFs: Global Economic Policy Uncertainty.

quarter h	θ^h	Average indirect effect: 90% Confidence interval Superior limit	Inferior limit	β^h	Low regime: 90% Confidence interval Superior limit	Inferior limit	β^h	High regime: 90% Confidence interval Superior limit	Inferior limit
0	0.42	0.92	-0.08	-0.75	0.83	-2.33	-0.01	0.98	-0.99
1	1.04	2.10	-0.01	-2.75	0.16	-5.66	-0.92	0.49	-2.32
2	1.48	2.63	0.32	-3.45	-0.38	-6.51	-0.84	0.76	-2.44
3	1.81	3.02	0.59	-4.53	-1.61	-7.45	-1.35	0.51	-3.21
4	2.50	4.40	0.60	-6.40	-2.21	-10.60	-2.00	0.55	-4.54
5	3.52	6.57	0.47	-9.23	-2.73	-15.74	-3.03	0.30	-6.35
6	3.92	8.07	-0.23	-10.45	-1.76	-19.13	-3.53	0.24	-7.31
7	4.15	9.58	-1.28	-11.09	0.27	-22.44	-3.77	0.62	-8.16
8	4.72	11.44	-1.99	-14.54	-0.47	-28.62	-6.22	-0.76	-11.68
9	4.71	11.46	-2.03	-16.61	-2.76	-30.46	-8.30	-3.16	-13.45
10	5.13	12.74	-2.48	-18.65	-2.49	-34.82	-9.61	-4.23	-14.99
11	6.78	15.63	-2.07	-24.72	-4.81	-44.64	-12.77	-5.53	-20.01
12	7.30	17.14	-2.54	-26.83	-2.67	-51.00	-13.96	-3.34	-24.58

Table 6: IRFs: Temperature Anomalies.

Appendix C: Robustness Exercises

This appendix show graphs for the robustness exercises mentioned in the main text. We present three sets: robustness checks to alternative lag structures for control variables, to changes in the specification to calculate the unpredictable movements in interest rates in the US, and to an alternative specification to estimate the state-dependent effects.

Robustness to both less and more lags of control variables

Figures 10 to 17 show the results when we control for both less and more lags of control variables relative to the level of lags in our benchmark specification. In short, we change the number of lags of control variables either to one or three. Results are essentially the same as those presented in the main text, confirming in all cases the existence of state-dependent effects of monetary policy.

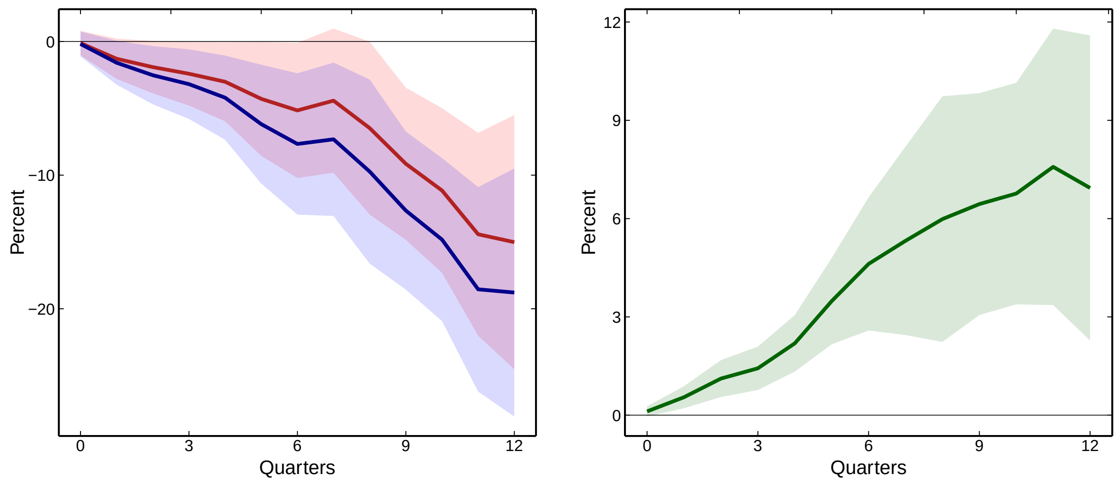

Figure 10: Robustness to controlling for less lags of covariates, for volatility state-dependent effects. Instead of controlling for two lags of covariates we control only for one. 90% confidence bands.

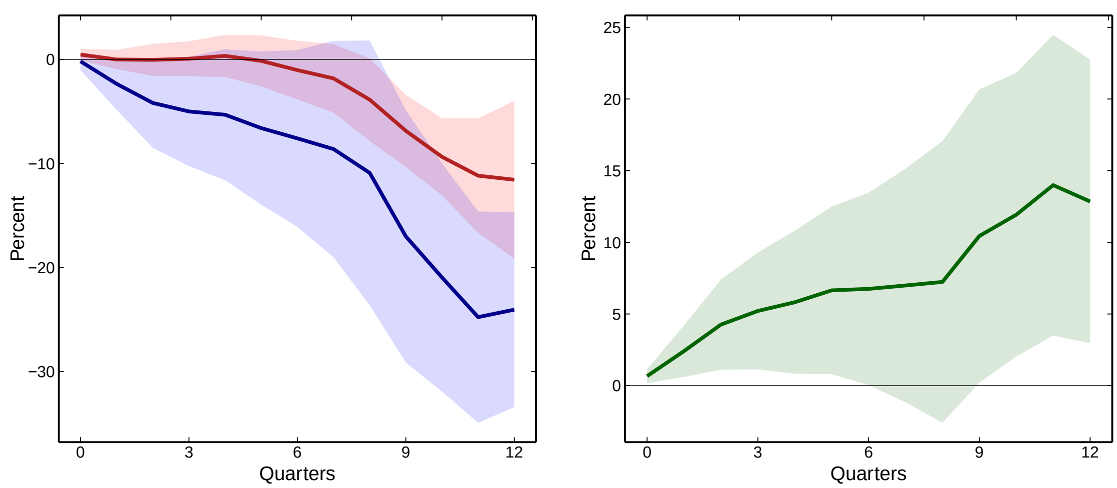

Figure 11: Robustness to controlling for less lags of covariates, for global supply chain state-dependent effects. Instead of controlling for two lags of covariates we control only for one. 90% confidence bands.

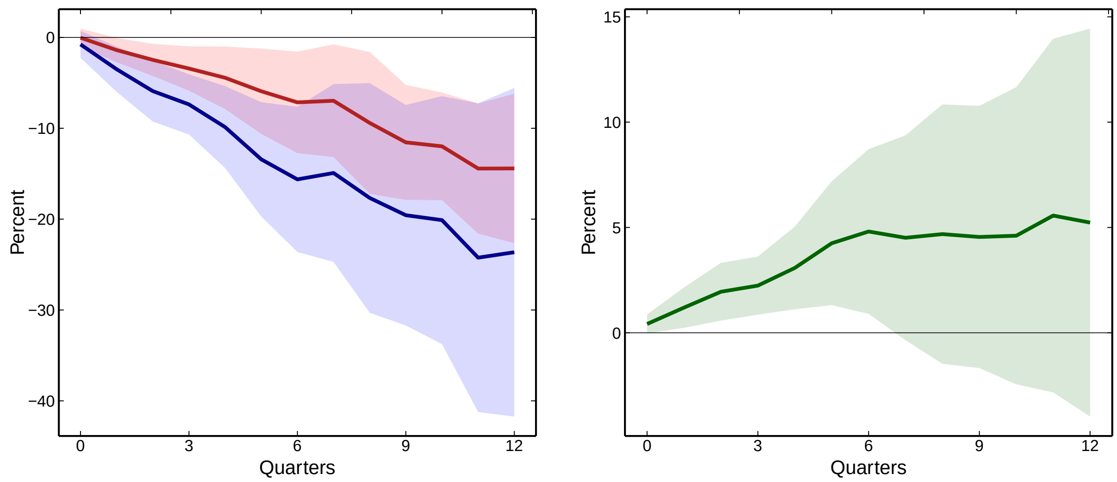

Figure 12: Robustness to controlling for less lags of covariates, for economic policy uncertainty state-dependent effects. Instead of controlling for two lags of covariates we control only for one. 90% confidence bands.

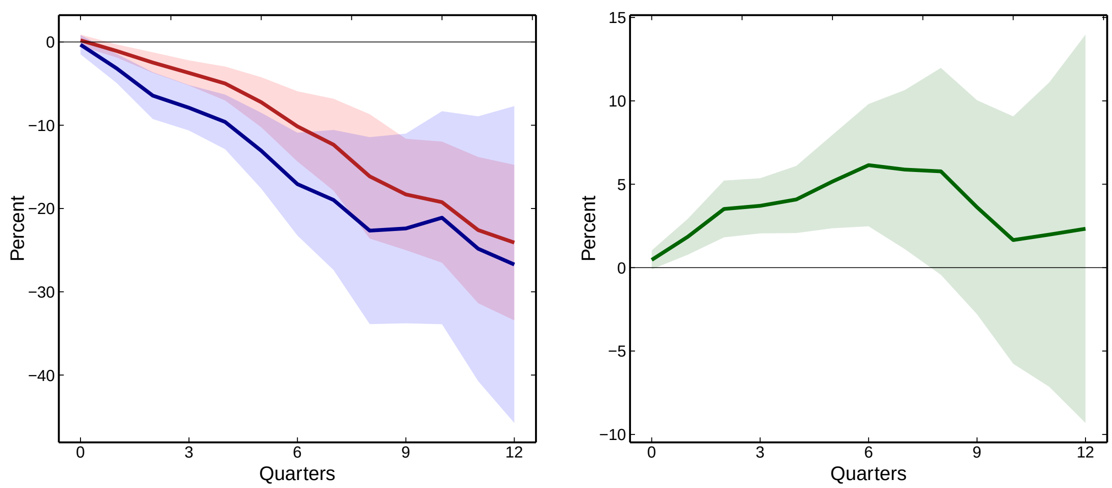

Figure 13: Robustness to controlling for less lags of covariates, for temperature anomalies state-dependent effects. Instead of controlling for two lags of covariates we control only for one. 90% confidence bands.

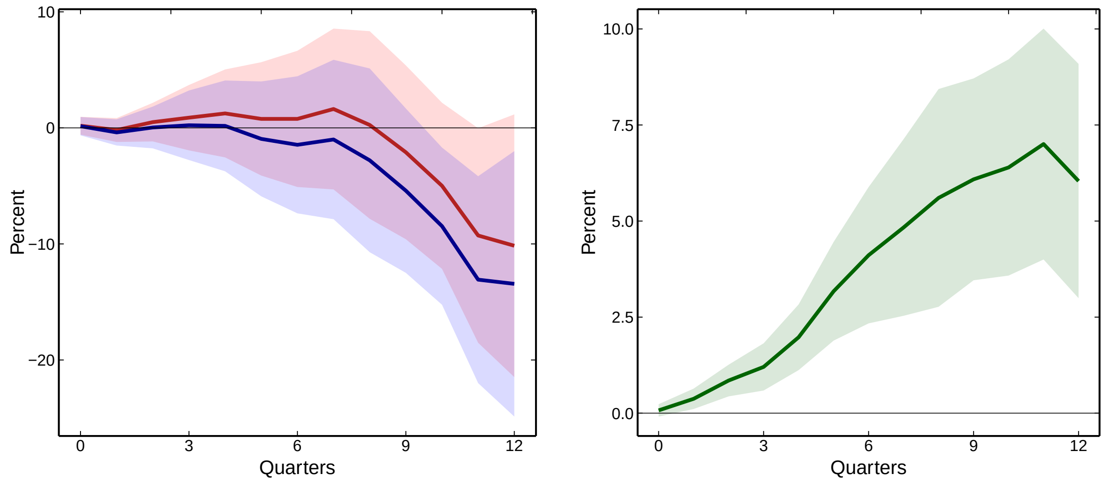

Figure 14: Robustness to controlling for more lags of covariates, for volatility state-dependent effects. Instead of controlling for two lags of covariates we control for three. 90% confidence bands.

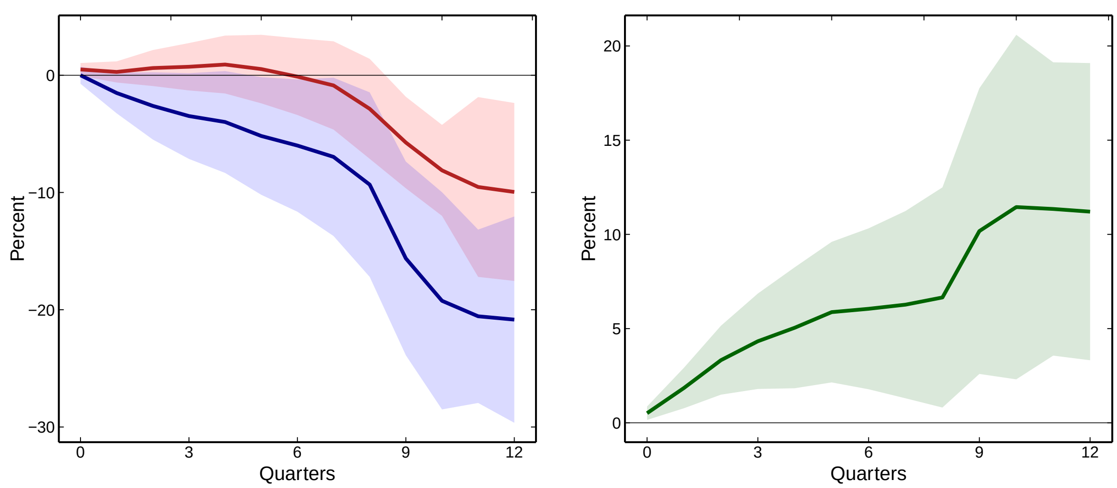

Figure 15: Robustness to controlling for more lags of covariates, for global supply chain state-dependent effects. Instead of controlling for two lags of covariates we control for three. 90% confidence bands.

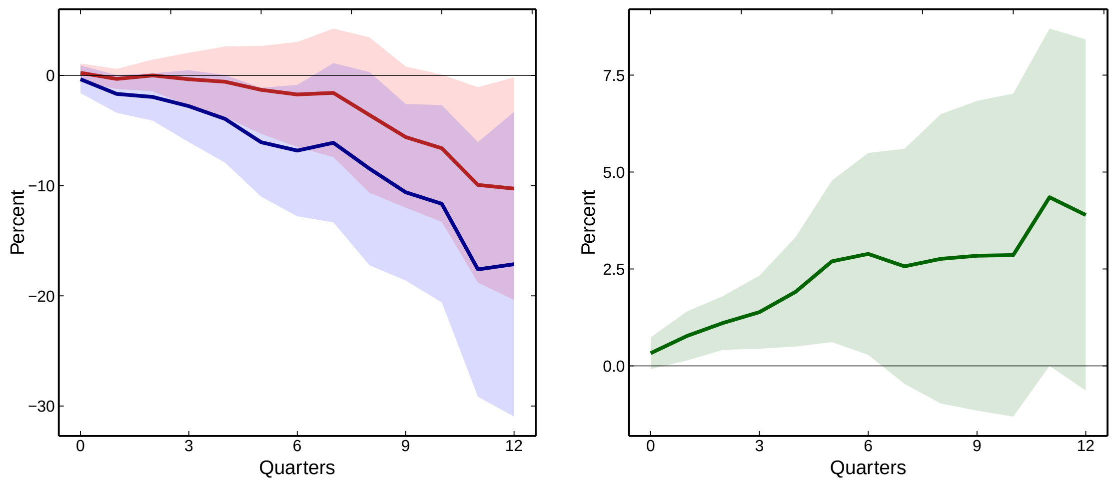

Figure 16: Robustness to controlling for more lags of covariates, for economic policy uncertainty state-dependent effects. Instead of controlling for two lags of covariates we control for three. 90% confidence bands.

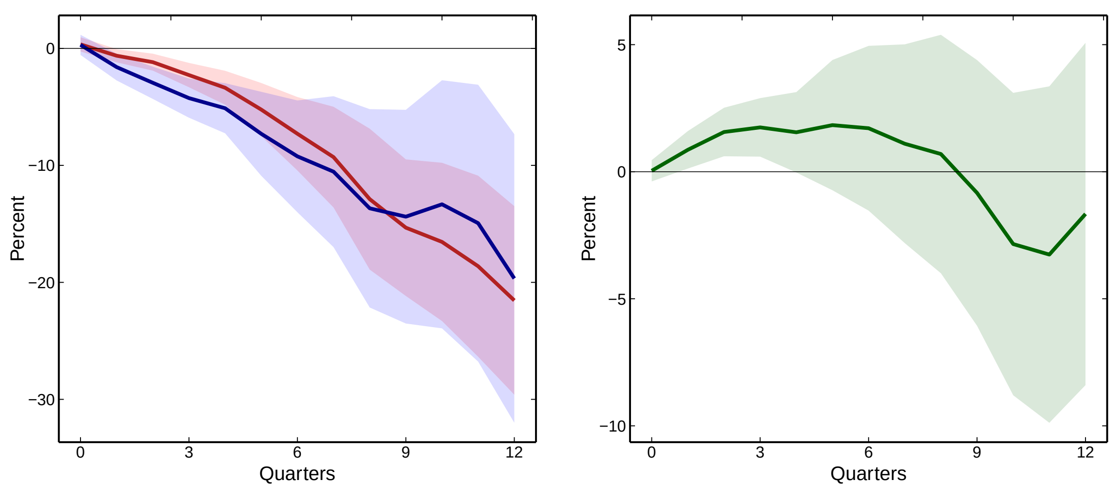

Figure 17: Robustness to controlling for more lags of covariates, for temperature anomalies state-dependent effects. Instead of controlling for two lags of covariates we control for three. 90% confidence bands.

Robustness to different calculations of unpredictable changes in US monetary policy

In this subsection, we present robustness exercises related to alternative ways of calculating the unpredictable change in US monetary policy, which is the fundamental component of our instrument. First, we change the number of lags of explanatory variables, to including both less and more lags. Second, we include an additional variable, inflation expectations, arguably crucial in capturing policy decisions by the Fed and thus important to really capture unpredictable changes. Results of all these checks are presented in Figures 18 to 29, and all of them confirm the main results.

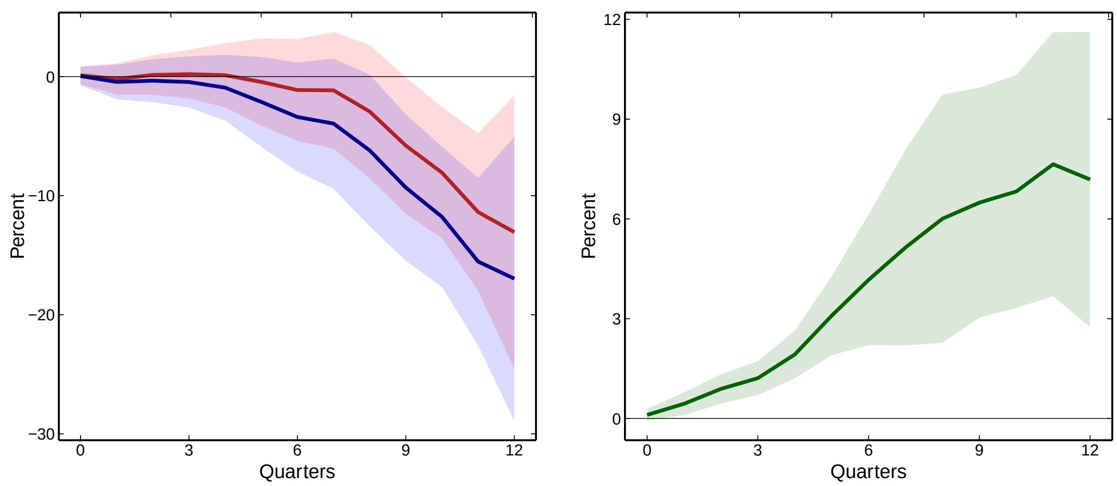

Figure 18: Robustness to different calculations of unpredictable changes in US monetary policy: the case of less lags of explanatory variables for volatility. Instead of controlling for two lags we control for one. 90% confidence bands.

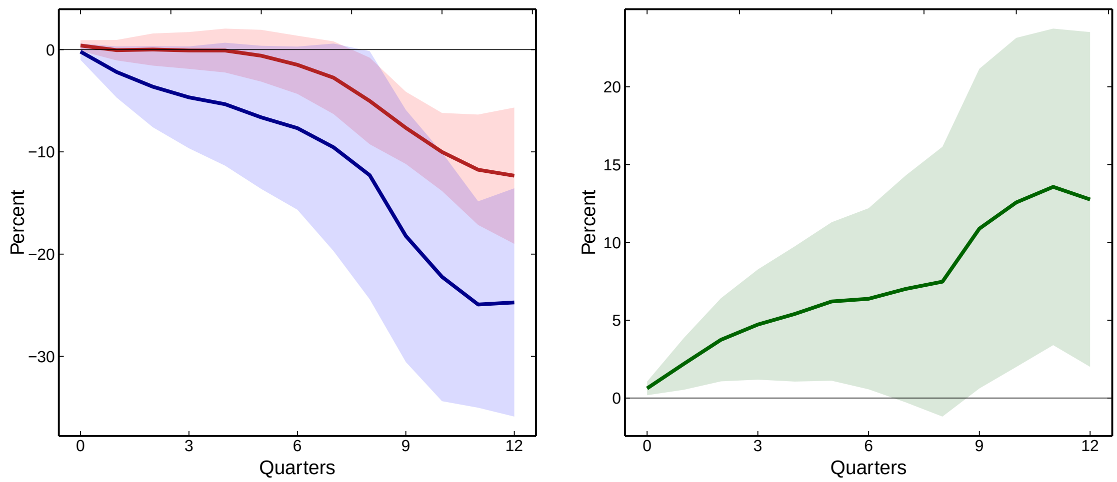

Figure 19: Robustness to different calculations of unpredictable changes in US monetary policy: the case of less lags of explanatory variables for global supply chain. Instead of controlling for two lags we control for one. 90% confidence bands.

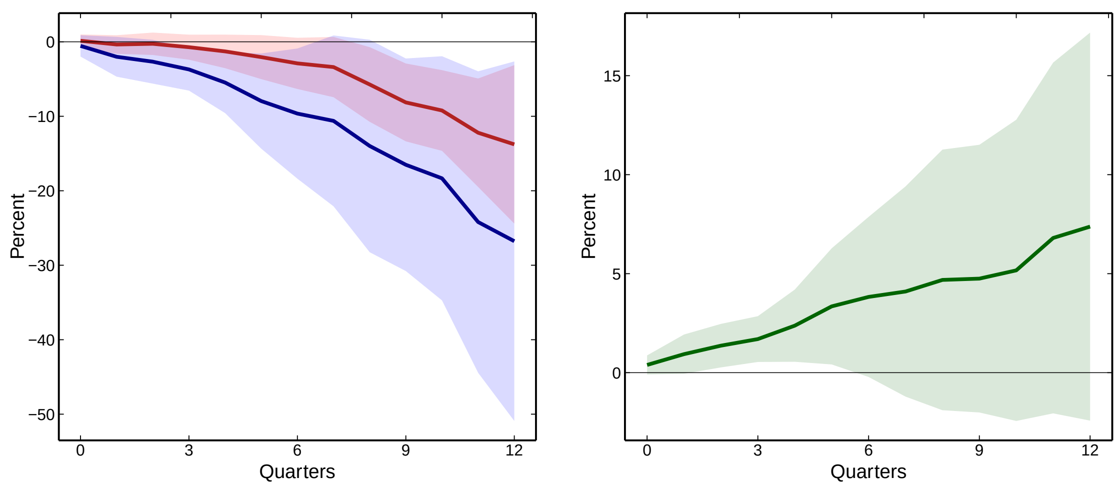

Figure 20: Robustness to different calculations of unpredictable changes in US monetary policy: the case of less lags of explanatory variables for economic policy uncertainty. Instead of controlling for two lags we control for one. 90% confidence bands.

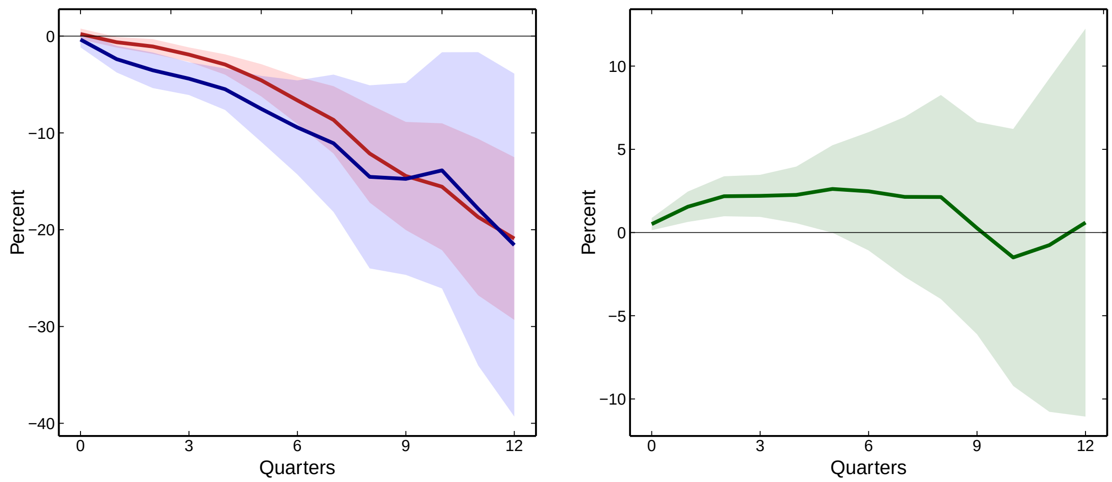

Figure 21: Robustness to different calculations of unpredictable changes in US monetary policy: the case of less lags of explanatory variables for temperature anomalies. Instead of controlling for two lags we control for one. 90% confidence bands.

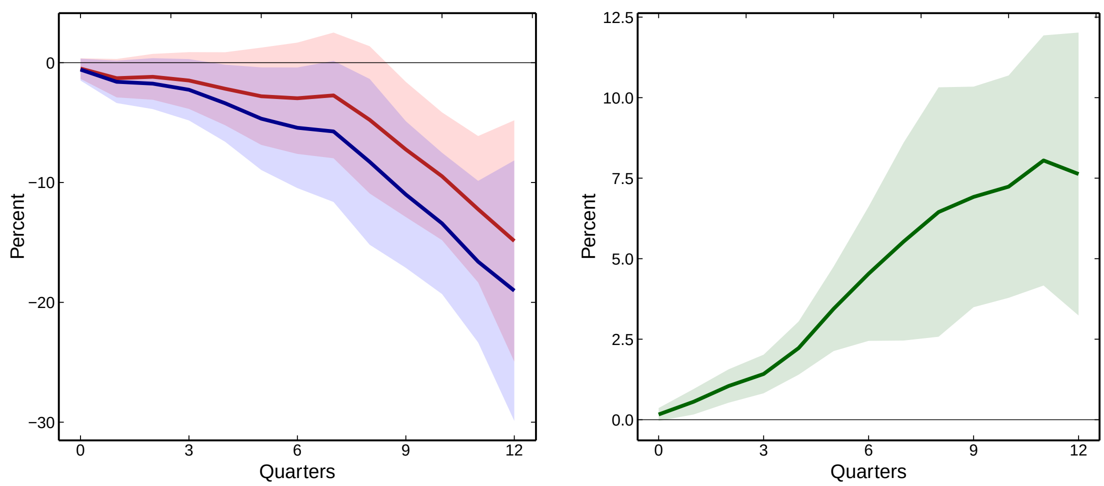

Figure 22: Robustness to different calculations of unpredictable changes in US monetary policy: the case of more lags of explanatory variables for volatility state-dependent effects. Instead of controlling for two lags we control for three. 90% confidence bands.

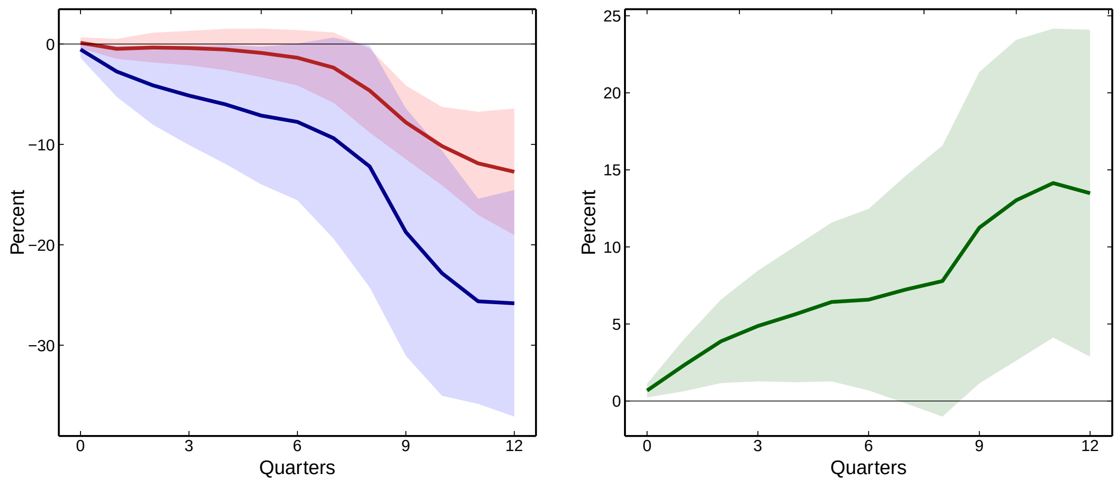

Figure 23: Robustness to different calculations of unpredictable changes in US monetary policy: the case of more lags of explanatory variables for global supply chain state-dependent effects. Instead of controlling for two lags we control for three. 90% confidence bands.

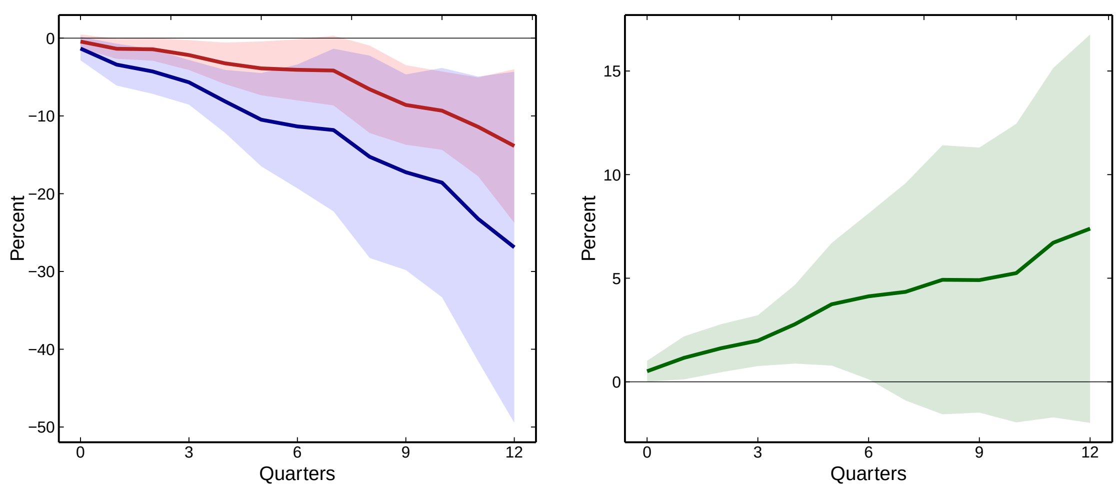

Figure 24: Robustness to different calculations of unpredictable changes in US monetary policy: the case of more lags of explanatory variables for economic policy uncertainty state-dependent effects. Instead of controlling for two lags we control for three. 90% confidence bands.

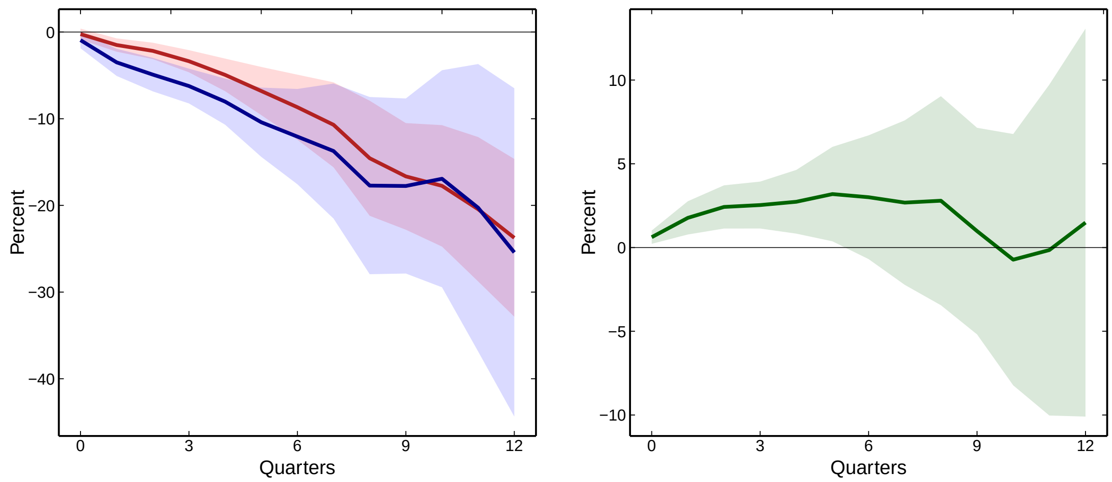

Figure 25: Robustness to different calculations of unpredictable changes in US monetary policy: the case of more lags of explanatory variables for temperature anomalies state-dependent effects. Instead of controlling for two lags we control for three. 90% confidence bands.

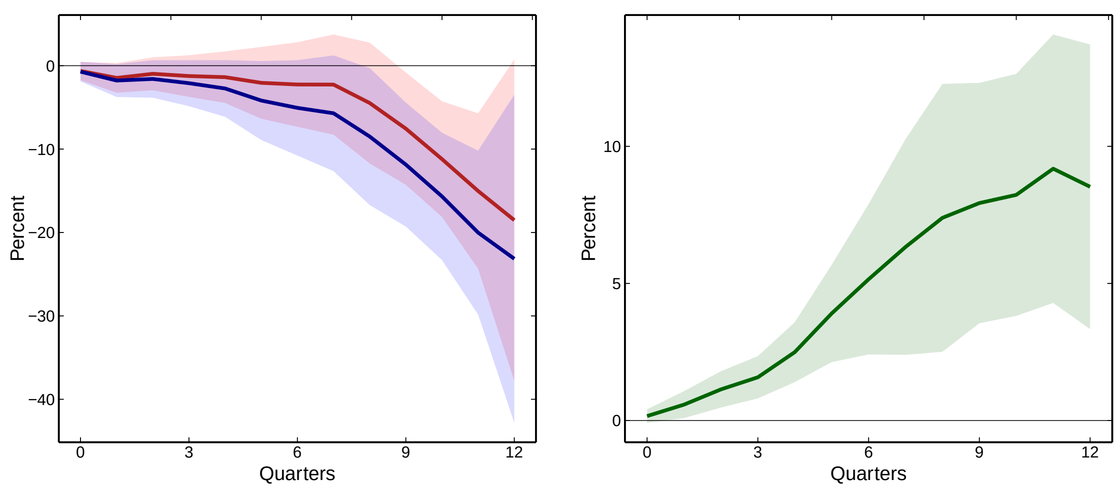

Figure 26: Robustness to different calculations of unpredictable changes in US monetary policy: the case of controlling for inflation expectations for volatility state-dependent effects. 90% confidence bands.

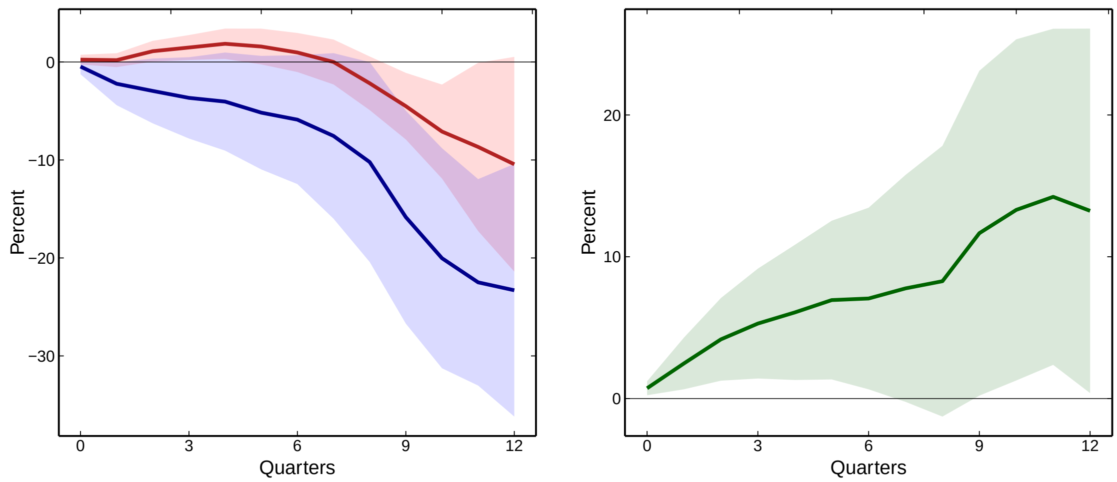

Figure 27: Robustness to different calculations of unpredictable changes in US monetary policy: the case of controlling for inflation expectations for global supply chain state-dependent effects. 90% confidence bands.

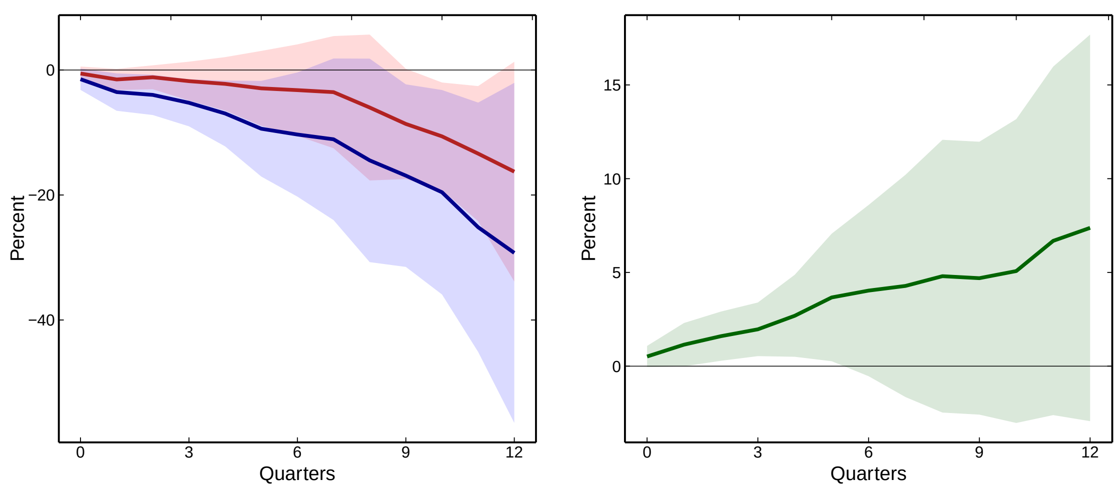

Figure 28: Robustness to different calculations of unpredictable changes in US monetary policy: the case of controlling for inflation expectations for economic policy uncertainty state-dependent effects. 90% confidence bands.

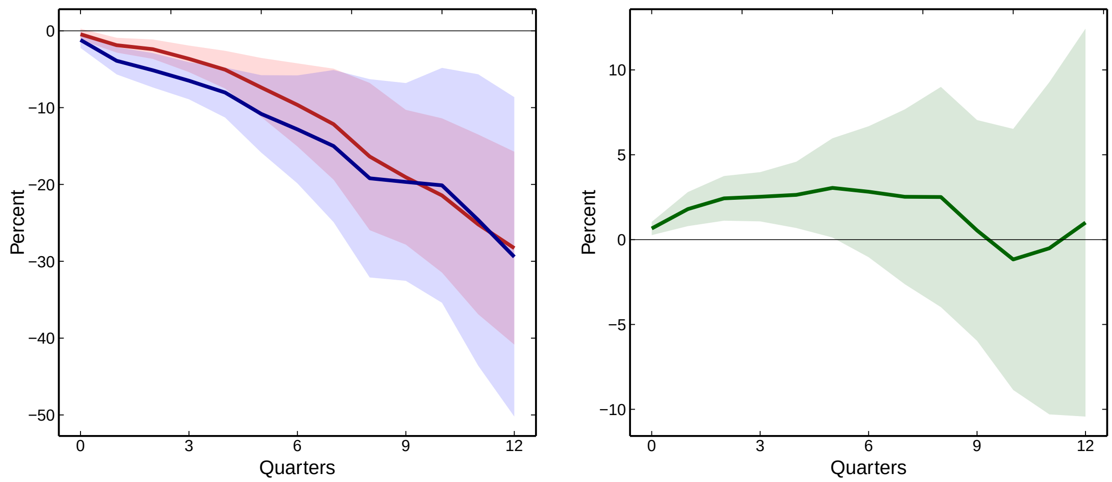

Figure 29: Robustness to different calculations of unpredictable changes in US monetary policy: the case of controlling for inflation expectations for temperature anomalies state-dependent effects. 90% confidence bands.

Robustness to an alternative specification to estimate the state-dependent effects

We further test if our state-dependent effects are driven by our baseline IV specification in equations 6 and 7. More specifically, instead of relying on only one first stage to predict exogenous variation in interest rates for EMEs, and then interacting it with the state variable, we use two separate first stages, one for changes in interest rates and a second for the interaction term itself. Formally, our alternative two-stages least squares system is given by the following three equations:

$$\Delta r_{i,t} \quad = \quad z_{i,t}\psi + \boldsymbol{x}'_{i,t}\delta + s_t\phi + \omega_i + u_{i,t} \tag{8}$$

$$s_t \Delta r_{i,t} \quad = \quad s_t z_{i,t} \psi^* + \boldsymbol{x}'_{i,t} \delta^* + s_t \phi^* + \omega_i^* + u_{i,t}^* \tag{9}$$

and,

$$y_{i,t+h} - y_{i,t-1} = \widehat{\Delta r_{i,t}} \beta^h + \widehat{s_t \Delta r_{i,t}} \theta^h + s_t \lambda^h + \boldsymbol{x}'_{i,t} \gamma^h + \mu_i^h + \nu_{i,t+h}, \quad h = 0, \dots 12 \tag{10}$$

where coefficients and the error term with an asterisk simply represent their values in the new first stage equation for the interaction term, aimed to show it is a different first stage equation than that for interest rate changes.

Results of this alternative way to estimate state-dependent effects are shown in Figures 30 to 33. The graphs reveal results that are quite similar to those found in the main text, and thus confirm that our results do not depend on the specific functional specification in the baseline.

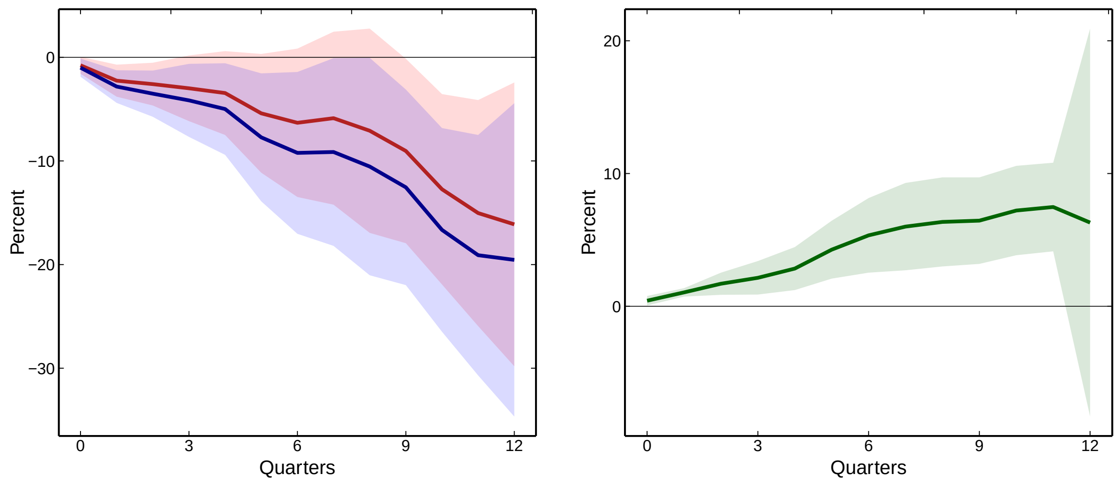

Figure 30: Robustness to using two first stages, the first for interest rate changes and the second for the interaction term: the case of volatility state-dependent effects. 90% confidence bands.

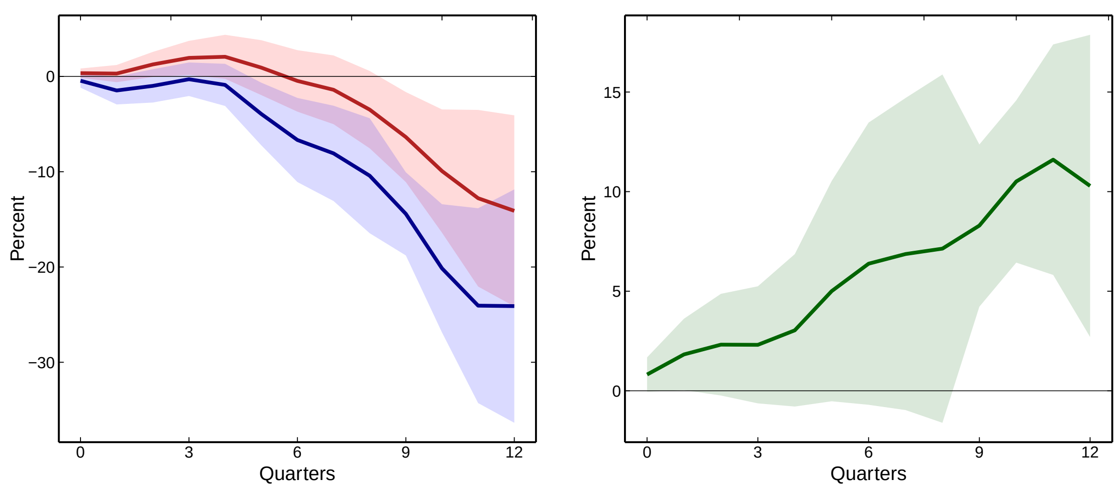

Figure 31: Robustness to using two first stages, the first for interest rate changes and the second for the interaction term: the case of global supply chain state-dependent effects. 90% confidence bands.

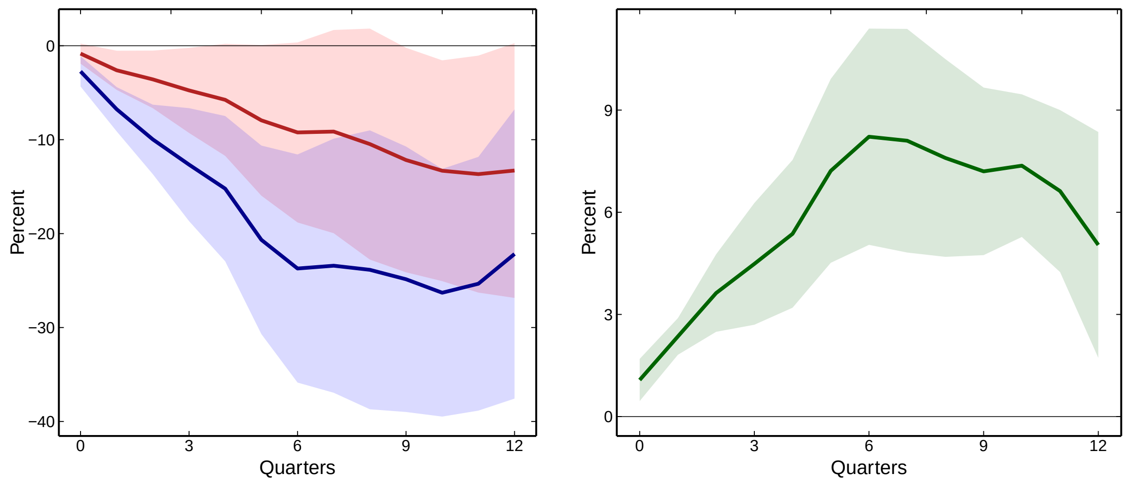

Figure 32: Robustness to using two first stages, the first for interest rate changes and the second for the interaction term: the case of economic policy uncertainty state-dependent effects. 90% confidence bands.

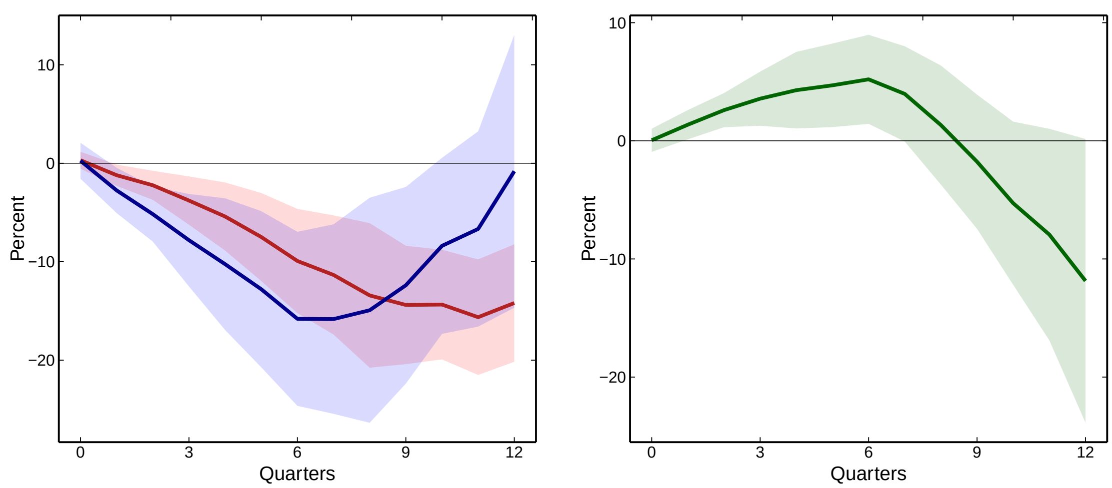

Figure 33: Robustness to using two first stages, the first for interest rate changes and the second for the interaction term: the case of temperature anomalies state-dependent effects. 90% confidence bands.