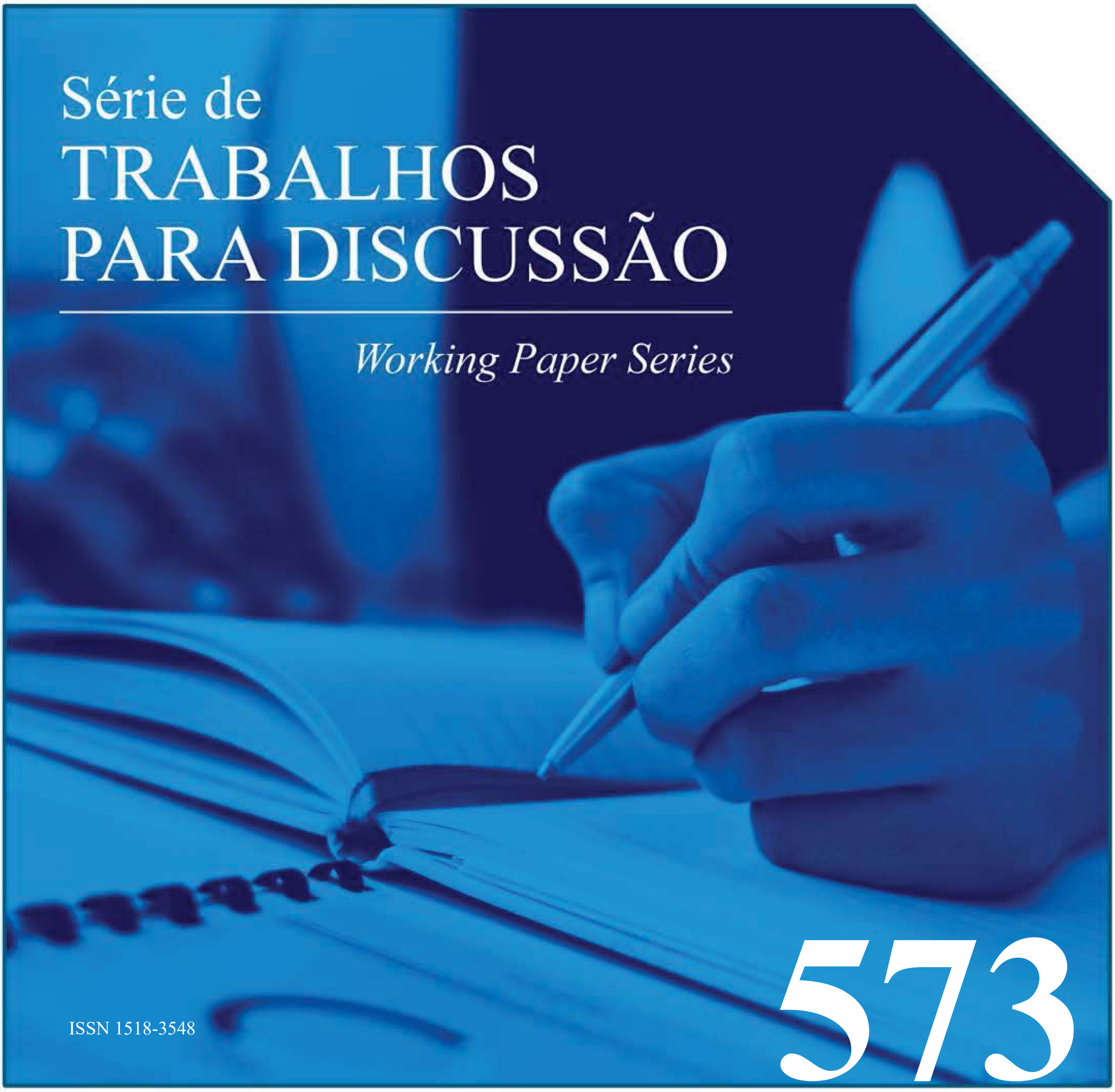

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Monetary Policy Surprises, Financial Conditions, and the String Theory Revisited

Leonardo Nogueira Ferreira

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Citizen Service Division

Banco Central do Brasil
Deati/Diate
SBS – Quadra 3 – Bloco B – Edifício-Sede – 2º subsolo
70074-900 Brasília – DF – Brazil
Toll Free: 0800 9792345
Fax: +55 (61) 3414-2553
Internet: http//www.bcb.gov.br/?CONTACTUS

Non-technical Summary

The literature on monetary policy witnessed several innovations in the last decades. On the estimation side, the study of different types of non-linearities has received a great deal of attention. On the identification side, new strategies such as the use of high-frequency surprises have contributed to refinements in the study of the causal effects of monetary policy shocks.

This paper is placed in the intersection of such advances. It allows asymmetry in the response of the economy to positive and negative monetary policy shocks, and it employs high-frequency surprises as instrumental variables. Since the window used to compute the surprises is very narrow, it is assumed the surprises are not affected by macroeconomic news other than the announcement.

Specifically, the central objective of this paper is to assess whether the dynamic responses of macroeconomic and financial variables to monetary shocks are asymmetric in recent US and euro area samples. Therefore, I revisit the "string theory", according to which monetary easings have smaller real effects than tightenings, and extend the analysis to the study of the dynamic responses of financial conditions. The study of potential asymmetries in the responses of all these variables is not only relevant by itself, but it can also help dissect what is behind the results in the symmetric case.

In order to do that, this paper makes use of local projections. Proposed by Jordà (2005), a local projection is a method to compute impulse responses that does not require the specification of the underlying multivariate dynamic system. Overall, results show robust evidence of asymmetry in the US and the euro area. In the US, for instance, industrial production, unemployment, and financial conditions respond more strongly to positive shocks (i.e., monetary tightenings) than to negative shocks, and prices respond more weakly to positive shocks than to negative shocks.

Sumário Não Técnico

A literatura sobre política monetária tem passado por várias inovações nas últimas décadas. Do lado da estimação, o estudo de diversos tipos de não linearidades tem recebido bastante atenção. Do lado da identificação, novas estratégias, como o uso de surpresas de alta frequência, têm contribuído para o refinamento do estudo dos efeitos causais de choques de política monetária.

Este artigo situa-se na intersecção de tais avanços. Permite assimetrias nas respostas da economia a choques positivos e negativos de política monetária, e emprega surpresas de alta frequência como variáveis instrumentais. Como a janela usada para calcular as surpresas é suficientemente curta, supõe-se que as surpresas não são afetadas por notícias macroeconômicas além do anúncio.

Especificamente, o objetivo central deste artigo é avaliar se as respostas dinâmicas de variáveis macroeconômicas e financeiras a choques de política monetária são assimétricas em amostras recentes dos EUA e da área do euro. Para tanto, a "teoria das cordas", segundo a qual afrouxamentos monetários têm efeitos reais menores do que os apertos, é revisitada. Ademais, a análise também é estendida para o estudo das respostas dinâmicas de condições financeiras. O estudo de potenciais assimetrias nas respostas de todas essas variáveis não é apenas relevante por si só, mas também pode ajudar a dissecar o que está por trás dos resultados no caso simétrico.

Para isso, este trabalho faz uso de *local projections*. Proposto por Jordà (2005), *local projection* é um método para calcular funções de resposta ao impulso que não requer a especificação do sistema dinâmico multivariado subjacente. Os resultados mostram evidências robustas de assimetria nos EUA e na área do euro. Nos EUA, por exemplo, produção industrial, desemprego e condições financeiras respondem mais fortemente a choques positivos (contrações monetárias) do que a choques negativos, e preços respondem mais fracamente a choques positivos do que a choques negativos.

Monetary Policy Surprises, Financial Conditions, and the String Theory Revisited

Leonardo N. Ferreira[*][†]

Abstract

Many are the attempts, by economists, at testing whether it is true that "you can't push on a string", reputedly John Maynard Keynes's words. Exploiting high-frequency surprises, this paper explores whether the responses of standard macroeconomic variables and financial conditions to monetary shocks are asymmetric in recent US and euro area samples. To this end, I estimate non-linear local projections using a Bayesian version of the procedure proposed by Lusompa (2021). Overall, results show robust evidence of asymmetry, with industrial production, unemployment, and financial conditions responding more strongly to monetary tightenings while CPI responds more weakly.

Keywords: Local Projections, Monetary Policy, High-frequency identification, Financial Conditions, Asymmetric Effects

JEL Classification: E30, E32, E44, E52, E58, C11, C50

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[*] Banco Central do Brasil and School of Economics and Finance, Queen Mary University of London, e-mail: leonardo.ferreira@bcb.gov.br.

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1 Introduction

Many are the attempts, by economists, at testing whether it is true that "you can't push on a string", reputedly John Maynard Keynes's words, according to which monetary easings have smaller real effects than tightenings. Ravn and Sola (2004), Tenreyro and Thwaites (2016), Angrist et al. (2018), and Barnichon and Matthes (2018) are only some of the examples. If changes in the policy rate are less powerful in any of the directions, central banks have to internalise this feature and act accordingly.

Given the policy relevance of this question, I revisit this topic and extend it in some dimensions. First, I exploit high-frequency changes around monetary policy announcements. High-frequency surprises have become a standard method of measuring monetary policy shocks because they can refine identification (Gürkaynak et al., 2005; Kaminska et al., 2021; Kuttner, 2001; Ramey, 2016). Since the window used to compute the surprise is very narrow, it is assumed the surprises are not affected by macroeconomic news other than the announcement.

Second, I estimate the model for a recent sample, which may lead to different conclusions for the real variables as reported by Ramey (2016). Furthermore, the study of asymmetries can help dissect what is behind the results in the linear case: it could be that positive shocks are driving the results for some variables, while negative shocks are driving the results for others. Third, I apply the same methodology to the euro area to investigate whether the results are general or US-specific.

Fourth, I also study the responses of financial conditions. The empirical literature on credit and financial conditions is growing fast. Brave and Butters (2011) produce financial condition indices that provide a timely assessment of how tightly or loosely financial markets are and contain information on future economic activity beyond that found in non-financial measures of economic activity.[1] Gilchrist and Zakrajšek

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[1] Many other papers have explored the link between financial conditions and economic activity. For instance, Aramonte et al. (2017) find predictive power of a selection of financial condition indices, especially if the financial crisis is included in the analysis. Hatzius et al. (2010) also build a new financial index that shows a tighter link with future economic activity.

(2012) show the component of credit spreads not explained by expected defaults has considerable predictive power. Alessandri and Mumtaz (2017) find credit and financial conditions are useful in forecasting.

Turning to the interaction with monetary policy, in a linear vector autoregressive (VAR) model, Gertler and Karadi (2015) find monetary shocks lead to enhanced movements in credit costs and the excess bond premium is one of the channels. Caldara and Herbst (2019) show the failure to account for the endogenous reaction of spreads causes attenuation in the response of all variables to monetary shocks. Carriero et al. (2020) highlight the role of credit market conditions as a source of asymmetry in the effects of monetary policy. They do so by employing a smooth transition model and find asymmetric effects are explained by how easings and tightenings affect credit conditions and the probabilities of regime changes differently.

The role played by financial conditions in the transmission of monetary policy is also highlighted in the official Fed communication. In the press conference that followed the July 2022 Federal Open Market Committee (FOMC) Meeting[2], for instance, Fed Chair Powell explained: "we set our policy, and financial conditions react, and then financial conditions are what affects the economy." In fact, the dynamic responses of financial conditions to monetary policy shocks are important not only per se but also in understanding the monetary transmission. It remains to be explored, however, whether the responses of financial conditions to monetary tightenings and loosenings are symmetric.

In order to investigate such issues, I use the local projection method of Jordà (2005). This approach is suitable in that it allows for the dynamic effects to be asymmetric in a simple way. Differently, however, I estimate a Bayesian version of the Generalised Least Squares (GLS) procedure proposed by Lusompa (2021). Lusompa (2021) shows that the autocorrelation process of local projections is known and that estimating the model with GLS is more efficient than standard estimation

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[2] https://www.federalreserve.gov/mediacenter/files/FOMCpresconf20220727.pdf.

with heteroskedasticity- and autocorrelation-consistent (HAC) standard errors. A Bayesian approach is convenient in that the sampling already takes into account the fact that estimates are used in the Feasible GLS (FGLS) transformation.

Furthermore, as pointed out by Stock and Watson (2018), high-frequency measures typically have measurement error, which can lead to bias if the measure is treated as the true shock. Hence, the surprises are treated as instruments in a Local Projection Instrumental Variable (LP-IV) set-up. As shown by Plagborg-Møller and Wolf (2021), this can be done by simply computing the ratio of reduced-form to first-stage coefficients. Estimating the model with Two-Stage Least Squares (2SLS) as it is usually done would allow only the first stage to be asymmetric while the dynamics would still be the same after both shocks.

Results show there is evidence of asymmetry for all the variables. Industrial production, unemployment, and the Financial Condition Index (FCI) respond more strongly to positive shocks than to negative shocks and the differences are 'significant' in a high posterior density interval (HPDI) sense. On the other hand, CPI responds more weakly to positive shocks than to negative shocks, especially at the beginning, possibly due to downward nominal rigidities. The main findings are similar when the methodology is applied to the euro area, so the asymmetry is not a specific feature of the US.

Therefore, this paper complements the literature by exploring the dynamic responses of financial conditions as well as revisiting the evidence for traditional macroeconomic variables in the US. The use of high-frequency surprises around policy announcements in the LP-IV also represents an advance in comparison with previous studies on asymmetry that implicitly rely on the strong identifying assumption of selection on observables. Equally important is the investigation of the effects in the euro area since, to my knowledge, this is the first paper to study potential asymmetries in the dynamic responses of the ECB's monetary policy.

The algorithm for the (non-)linear reduced-form BLP can also be applied to many other economics questions involving asymmetry, or not, provided that a measure of shock or an instrument is available. The rest of the paper is organised as follows. Section 2 describes the data. Section 3 introduces the econometric approach. Section 4 presents the results for the US, followed by evidence on the euro area in Section 5. Section 6 concludes.

2 Data

The model is estimated using US data on the fed funds rate (FFR), the consumer price index (CPI), the industrial production index (IP), the unemployment rate, and the FCI. FFR, FCI, and unemployment are in levels and the remaining variables are in log levels. The data are monthly and run from 1987M11 to 2020M02.

The FCI used here is constructed by the Chicago Fed using a dynamic factor model and represents a single common factor that captures financial conditions in money markets, debt and equity markets, and the traditional and "shadow" banking systems.[3] Therefore, in addition to allowing the study of the responses of financial conditions, its inclusion in the set of variables increases the informational content of the model, essentially turning it into a factor-augmented local projection.

To identify all these effects, I use monetary policy surprises. Following Paul (2020), high-frequency surprises are extracted from the current-month fed funds futures and adjusted for the remaining days within a month, as suggested by Kuttner (2001).[4] The surprises are calculated based on a 30-minute window around scheduled FOMC meetings and are relatively balanced between positive and negative values: 42% of them are positive. In practice, they are virtually zero during the zero lower

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[3] The index is constructed to have an average value of zero and a standard deviation of one over a sample period extending back to 1971. More information can be found on the Chicago Fed website (https://www.chicagofed.org/research/data/nfci/background), Brave and Butters (2011), and Brave and Butters (2012).

[4] This measure was later coined MP1 by Gürkaynak et al. (2005). It is highly correlated with standard measures of conventional monetary policy such as Gürkaynak et al. (2005)'s target factor but not so close to Inoue and Rossi (2021) approach in that it focus on shifts in the interest rate at the shortest maturity as usual while the latter use shifts in the whole term structure. Paul (2020) presents detailed evidence that suggests MP1 provides a strong instrument to identify monetary policy shocks and is less likely to be contaminated with information effects, especially when only scheduled meetings are used.

bound period, but keeping this episode in the sample allows estimating the effects in the period following it as in Paul (2020).[5]

3 Econometric Framework

3.1 Linear Local Projections

The point of departure for the analysis is the local projection method of Jordà (2005):

$$y_{t+h} = \beta_h \varepsilon_t + \gamma_h x_t + u_{t+h} \tag{1}$$

where y_{t+h} is a vector of n monthly macroeconomic and financial variables, with $h = 0, ..., H$ denoting the horizons. ε_t are the high-frequency surprises, β_h gives the conventional direct estimates of the impulse responses, and x_t collects the controls: P lags of the endogenous variables and of the proxy, the intercept, and a linear trend. Finally, u_{t+h} denotes the residuals.

High-frequency surprises ε_t are useful to address endogeneity concerns, but typically have measurement error that can lead to bias if treated as the true shock (Stock and Watson, 2018). Hence, the monetary surprises are treated as instruments in a Local Projection Instrumental Variable (LP-IV) approach, whereby equation (1) represents both the reduced-form and the first-stage regressions. As shown by Plagborg-Møller and Wolf (2021), the LP-IV approach can be implemented by simply calculating the ratio of reduced-form to first-stage coefficients $\beta_{LPIV,h} \equiv \beta_h/\beta_{FS}$ where β_{FS} is the term in β_0 from the equation for FFR, i.e. the response of FFR on impact.

The residuals u_{t+h} are serially correlated since they are a combination of one-step-ahead forecast errors. Previous studies (e.g. Jordà (2005); Miranda-Agrippino and Ricco (2021); Ramey (2016)) have treated this autocorrelation process as unknown

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[5] The series of monetary surprises is presented in the appendix.

and dealt with this issue by incorporating corrections for serial correlation such as Newey and West (1987). However, Lusompa (2021) shows the autocorrelation process of local projections is known and proposes a more efficient correction. Taking advantage of the fact that the residuals u_{t+h} are VMA(h) even if the true model is not a VAR, he introduces a consistent GLS estimator that involves transforming the data and estimating the regressions as follows:

1. Estimate the horizon 0 LP

$$y_t = \beta_0 \varepsilon_t + \gamma_0 x_t + u_t$$

which is equivalent to a VAR, implying $u_t = \epsilon_t$, where ϵ_t denotes the VAR forecast error terms.

2. Using the estimates of ϵ_t and $\gamma_0^{(1)}$ (the elements of γ_0 associated with the first lag), do the GLS transformation

$$\tilde{y}_{t+1} = y_{t+1} - \hat{\gamma}_0^{(1),OLS} \hat{\epsilon}_t \tag{2}$$

and estimate the horizon 1 LP replacing y_{t+1} with $\tilde{y}_{t+1}$ in equation (1).

3. For each horizon $h = 2, ..., H$, repeat this recursive procedure and estimate the local projections using the transformed $\tilde{y}_{t+h}$ that can be generalised as

$$\tilde{y}_{t+h} = y_{t+h} - \hat{\gamma}_{h-1}^{(1),GLS} \hat{\epsilon}_t - ... - \hat{\gamma}_0^{(1),OLS} \hat{\epsilon}_{t+h-1} \tag{3}$$

This procedure cleanses the left-hand variables from $\hat{\epsilon}_{t+h}$, eliminating the autocorrelation in local projections (see Lusompa (2021) for details).

3.2 Non-linear Local Projections

In order to investigate asymmetry, I also apply this GLS transformation to the local projections implemented by Tenreyro and Thwaites (2016):

$$y_{t+h} = \beta_h^- \max\{0, \varepsilon_t\} + \beta_h^+ \min\{0, \varepsilon_t\} + \gamma_h x_t + u_{t+h} \tag{4}$$

or, equivalently,

$$y_{t+h} = \tilde{\beta}_h \varepsilon_t + \tilde{\beta}_h^+ \max\{0, \varepsilon_t\} + \gamma_h x_t + u_{t+h} \tag{5}$$

where positive and negative shocks are allowed to have different effects: β_h^- and β_h^+, with $\beta_h^- = \tilde{\beta}_h$ and $\beta_h^+ = \beta_h + \tilde{\beta}_h^+$. Differently, however, I adjust these conventional estimates of the impulse responses using the correction for non-linearities proposed by Gonçalves et al. (2021). They show local projection estimators currently used in the literature, which effectively ignore the non-linearity of the impulse responses, are invalid. This can be seen by applying the definition of non-linear impulse response to equation (5)

$$IRF_{h,\delta} = E(y_{t+h}(\delta) - y_{t+h})$$

where δ is the size of the shock, and

$$y_{t+h}(\delta) - y_{t+h} = \tilde{\beta}_h^+ [\max\{0, \varepsilon_t + \delta\} - \max\{0, \varepsilon_t\}] + \tilde{\beta}_h [\varepsilon_t + \delta - \varepsilon_t]$$

which can be written as follows:

$$y_{t+h}(\delta) - y_{t+h} = \tilde{\beta}_h^+ [\max\{0, \varepsilon_t + \delta\} - \max\{0, \varepsilon_t\}] + \tilde{\beta}_h \delta$$

It is easy to see that when there is no non-linear term, this expression boils down to $\tilde{\beta}_h \delta$ (or just $\tilde{\beta}_h$ when $\delta = 1$) since the square brackets multiplying this term becomes simply δ. However, that is not the case with the first square brackets, where the non-linearity appears. Therefore, existing studies that interpret the raw β's as the impulse response in the non-linear case are implicitly assuming $[\max\{0, \varepsilon_t +$

$\delta\} - \max\{0, \varepsilon_t\}] = \delta$, being, therefore, unable to recover the population response functions even asymptotically.

Nevertheless, when ε_t is i.i.d, the correction assumes a very simple form and the construction of the modified LP estimator amounts to estimating the term in brackets and adjusting the standard impulse response as follows:

1. Obtain an estimate of $A_{0,\delta} \equiv E[\max\{0, \varepsilon_t + \delta\} - \max\{0, \varepsilon_t\}]$ as[6]

$$\hat{A}_{0,\delta} \quad = \tfrac{1}{T} \textstyle\sum_{t=1}^{T} (\max\{0, \varepsilon_t + \delta\} - \max\{0, \varepsilon_t\})$$

2. Then compute

$$IRF^{LP}_{h,\delta^+} \quad = \tilde{\beta}_h \delta + \tilde{\beta}^+_h \hat{A}_{0,\delta}$$

The adjustment for non-linearity depends on $\hat{A}_{0,\delta}$, which is the sample average of the difference between the non-linear functions $\max(\cdot)$ evaluated at '$\varepsilon_t + \delta$' and 'ε_t', and enables the consistent estimation of the population impulse responses as demonstrated by Gonçalves et al. (2021).

3.3 Estimation

Modelling the autocorrelation process allows for a fully Bayesian approach. Specifically, a Monte Carlo sampler with a conjugate flat prior (described in the appendix) is employed.[7] The baseline model is estimated with 12 lags. It is crucial that the number of lags be large enough so that the residuals from the first LP are uncorrelated (Lusompa, 2021).

A Bayesian approach is particularly convenient in that i) LP-IV inference becomes straightforward and only requires the computation of the ratio of

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[6] Note this is just the non-linear counterpart of the impulse given in the traditional linear IRF which is given by δ since: $\frac{1}{T}\sum_{t=1}^{T}(f(\varepsilon_t + \delta) - f(\varepsilon_t)) = \frac{1}{T}\sum_{t=1}^{T}((\varepsilon_t + \delta) - \varepsilon_t) = \delta$.

[7] Even though, in principle, an informative prior based on a training sample could also be used, this would make the remaining sample period even shorter.

reduced-form to first-stage coefficients for each draw; and ii) the sampling naturally takes into account the fact that estimates are used in the FGLS transformation. By using draws of ϵ_t, ..., ϵ_{t+h-1} and of $\gamma_0^{(1)}$, ..., $\gamma_{h-1}^{(1)}$ in the transformation described in equations (2) and (3), the algorithm properly captures the uncertainty arisen from the fact that $\hat{\epsilon}_t$, ..., $\hat{\epsilon}_{t+h-1}$ are used in place of the unobserved ϵ_t, ..., ϵ_{t+h-1} and $\hat{\gamma}_0^{(1)}$, ..., $\hat{\gamma}_{h-1}^{(1)}$ in place of $\gamma_0^{(1)}$, ..., $\gamma_{h-1}^{(1)}$. The posterior is simulated based on 1,000 draws.

4 Results

Figure 1 displays the impulse responses after a monetary policy shock, normalised to have an impact of 25 basis points on the federal funds rate. The grey shaded area represents the 68 percent HPD credible sets, and the blue line represents the median.

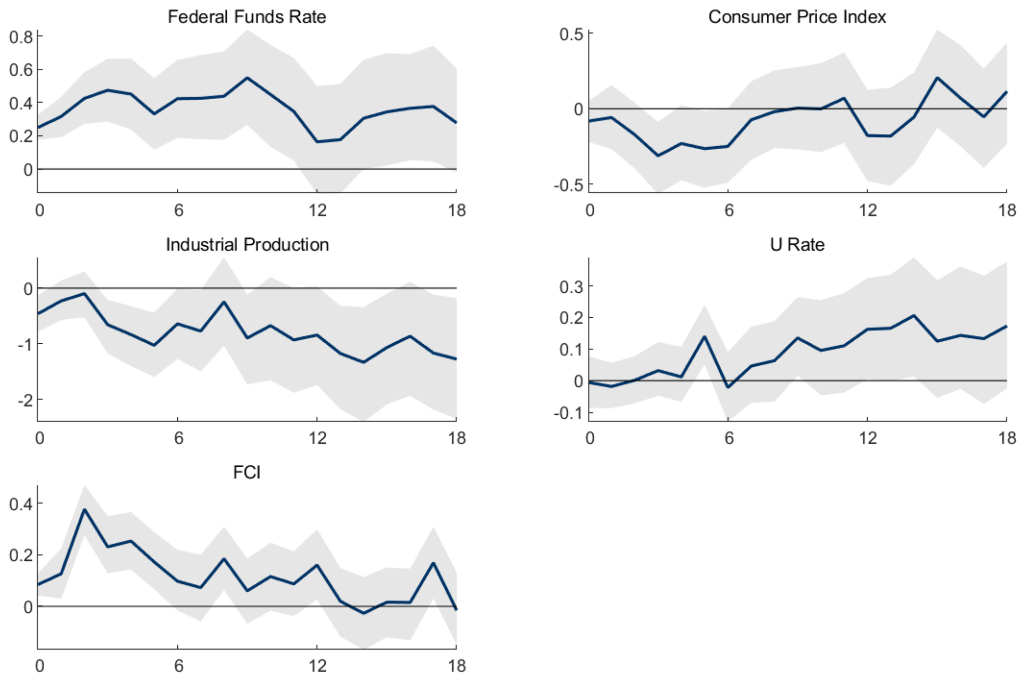

Figure 1: Impulse responses: linear case

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The monetary policy shock has been normalised to have an impact of 25 basis points on the federal funds rate.

CPI goes down after some time, but the effect is only temporary. Differently, industrial production displays a persistent decrease. The unemployment rate increases, but the credible set becomes very wide, so there is high uncertainty for longer horizons. FCI goes up indicating tighter financial conditions, and this fades away only in approximately one year. Overall, results are consistent with the literature (Gertler and Karadi, 2015; Miranda-Agrippino and Ricco, 2021; Paul, 2020).

Albeit more erratic as it is usually the case with local projections, such responses are very similar to the ones produced by a Proxy VAR presented in Figure 2. This is not surprising since Plagborg-Møller and Wolf (2021) show local projections and VARs estimate the same impulse responses in population. Such equivalence, however, does not hold in the non-linear case.

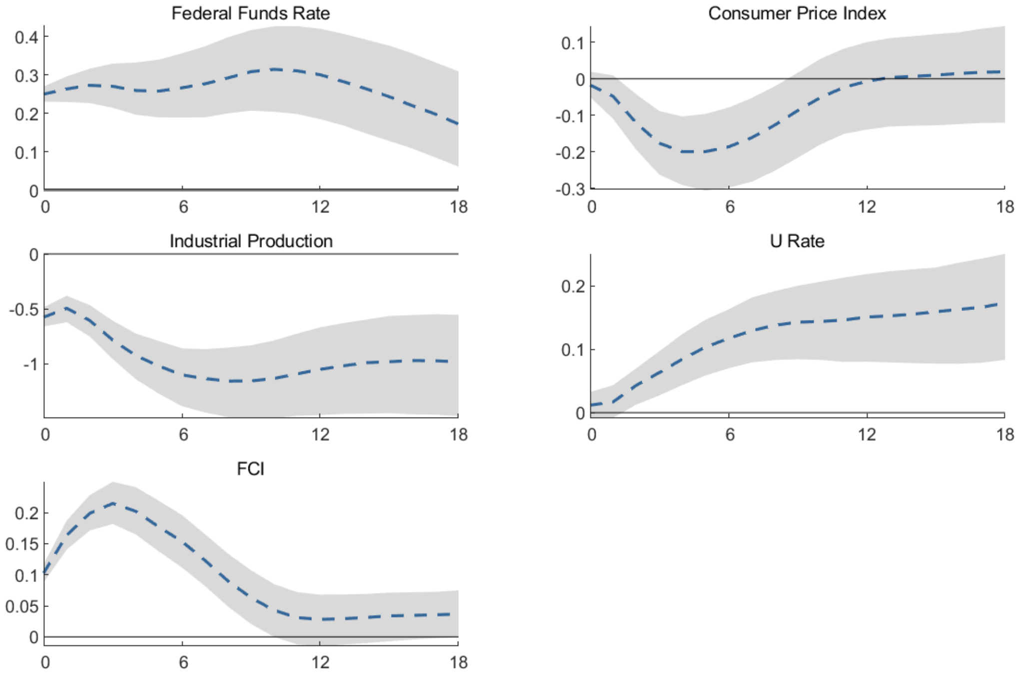

Figure 2: Impulse responses: linear case

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The monetary policy shock has been normalised to have an impact of 25 basis points on the federal funds rate.

Figure 3 compares the impulse responses after positive and negative shocks based on local projections. Specifically, it shows the IRFs after a tightening in the first column, the flipped IRFs after a loosening in the second column, and the difference between them in the last column. As in the linear case, the impact on the fed funds rate is normalised on impact. Nevertheless, the response after a loosening shows more persistence than the response to a tightening.

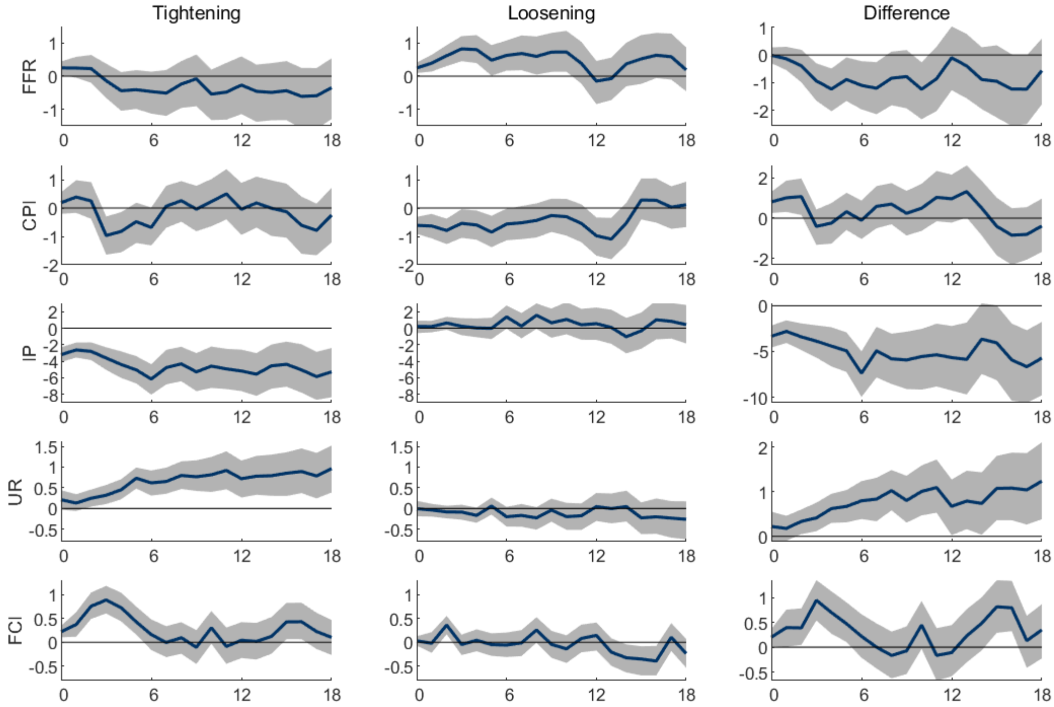

Figure 3: Impulse responses: positive and negative shocks

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The left panel presents impulse responses to positive shocks. The central panel shows the impulse responses to negative shocks. They are flipped to facilitate comparison. The right panel shows their difference. The monetary policy shock has been normalised to have an impact of 25 basis points on the federal funds rate.

CPI goes down after a positive shock, but this is only borderline "significant". On the other hand, there is a stronger and steadier response to a negative shock. This more persistent behaviour of CPI after a loosening can be at least partially accounted for the persistence in the fed funds ratio. Given the uncertainty, however, this does not produce a difference in an HPDI sense for the longer horizons.

The main source of the difference in the right column is the fact that prices do not react on impact to a tightening, what is consistent with theories of downward nominal rigidities. It is also worth noting that the version without lags of the proxy displays a price puzzle after a positive shock, highlighting the importance of controlling for lags of ε and $f(\varepsilon)$ as suggested by Gonçalves et al. (2021).[8]

The response of industrial production after a tightening is very similar to the one displayed in Figure 1. In fact, it seems positive shocks are the main drivers of the response in the linear case as industrial production does not react to negative shocks in this sample. As a consequence, there is a large difference between them. The responses of the unemployment rate mirror the ones of industrial production. The unemployment rate increases persistently after a tightening without any significant reaction after a loosening. Accordingly, the difference in an HPDI sense is also persistent and "significant".

Despite the difference in terms of sample and identification, such responses are in line with previous studies, such as Angrist et al. (2018) and Debortoli et al. (2020) among others. Theoretical macro models encompassing downward nominal rigidities, menu costs and other types of frictions also set the ground for asymmetry in prices and real variables, with monetary easings having smaller real effects than tightenings in line with the words attributed to Keynes.

The behaviour of financial conditions is also asymmetric. FCI responds more strongly to positive shocks than to negative shocks, displaying a difference in an HPDI sense. This behaviour, coupled with the "balance sheet" channel reviewed by Bernanke and Gertler (1995), amplifies the movements and, therefore, the asymmetry in the industrial production and the unemployment rate.

Empirical benchmarks for financial and credit conditions in a set-up that allows for asymmetry are not so easy to find. Carriero et al. (2020) explore different sizes of shocks and different regimes, and find effects that are sometimes not different than zero and sometimes only borderline "significant".

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[8] See the appendix.

4.1 Robustness

Some additional robustness checks are conducted, and similar results can be obtained when estimating different specifications as shown in the appendix. First, the sample ends before the zero lower bound period (in 2007M12). In this case, impulse responses are less precisely estimated given the large reduction in the sample period. There is a small price puzzle following a loosening and this affects the comparison. Apart from that, overall conclusions are maintained.

Second, Swanson (2021)'s factors are used in the regression. This offers an opportunity both to check if results are robust to the use of an alternative instrument (FFR factor) and to control for forward guidance (FG factor) and Fed's asset purchases (LSAP factor). Even using an LP-IV, given the scale of these interventions and the frequency in the use of these tools, it is prudent to control for unconventional monetary policy as a robustness check. Except for CPI, whose difference is now only slight - positive at the beginning as in the benchmark, but positive at some later horizons -, the main conclusions remain the same.

Finally, FCI is replaced with the excess bond premium and the BAA spread. Even though they are narrower measures since they are constructed using exclusively spreads on non-financial corporate bonds, they are broadly used in this literature (Caldara and Herbst, 2019; Gertler and Karadi, 2015). Once more, results are similar.

5 Euro area

This section employs the same methodology to euro area data. This helps understand whether the results presented in previous sections are US-specific or more general.

5.1 The euro area dataset

The local projections are estimated on the German 1-year government bond yield in order to capture the safest one-year interest rate as in Jarociński and Karadi (2020), the harmonised index of consumer prices (HICP), the industrial production index (IP), the unemployment rate, and the spread non-financial corporate euro area with respect to the German yield, built by Gilchrist and Mojon (2018), to capture financial conditions.[9] They show credit spreads provide substantial predictive content for a variety of real activity and lending measures for the euro area.

The sample runs from 1999M01 to 2020M02, and to identify the effects for the euro area, I use the updated monetary policy shocks of Jarociński and Karadi (2020).[10] They are based on the co-movement of the high-frequency surprises of interest rates and stock prices around policy announcements, which allow the disentangling of monetary policy and the central bank's assessment of the economy. As the authors show, measures free of information effects are crucial to achieving unbiased inference.

5.2 The euro area results

Figure 4 displays the impulse responses for the euro area in the linear case. Prices go down as expected and the effect is longer-lasting than the effect found in the US. Industrial production and unemployment rate, on the other hand, do not react to a monetary tightening whereas the spread goes slightly up.

Figure 5 shows the impulse responses after positive and negative shocks, and their differences. Once more, the response of prices after a loosening is slightly

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[9] This choice differs from the US baseline specification because the FCI for the euro area constructed by Petronevich et al. (2019) is available only since 2008.

[10] This series is available on Marek Jarocinsky's webpage. An alternative closer to the US specification would be to use Altavilla et al. (2019)'s rate factor. However, besides reducing the sample period even further, this would bring little information for the estimation of the impulse responses since, in contrast to the US, the euro area has been in the zero lower bound for a large portion of the sample period.

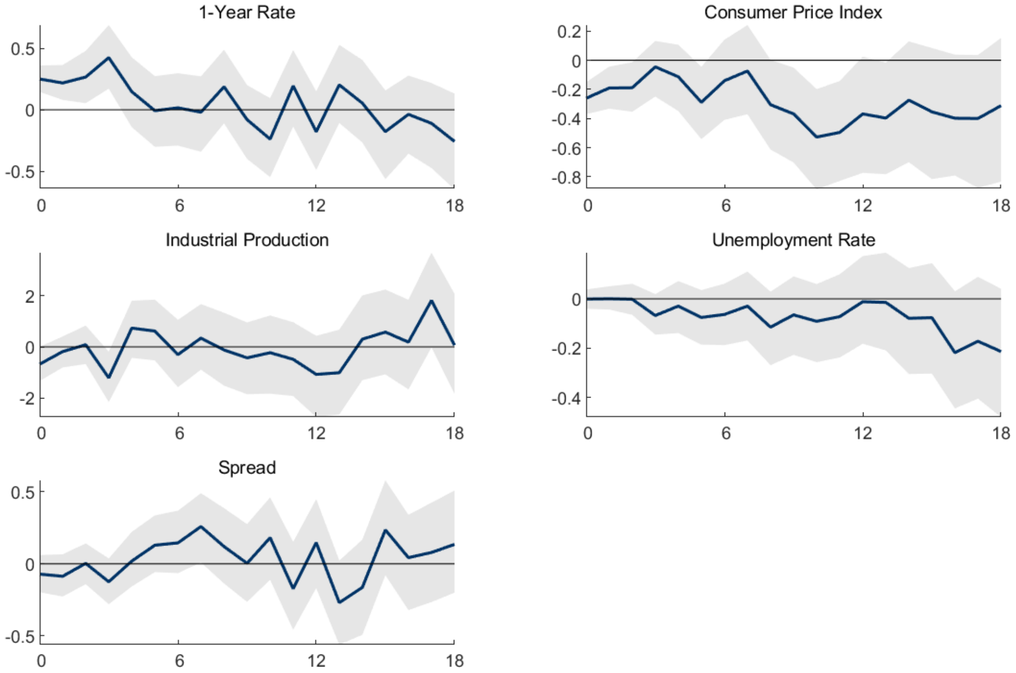

Figure 4: Impulse responses: linear case

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The monetary policy shock has been normalised to have an impact of 25 basis points on the German 1-year rate.

stronger than the response to a tightening although the difference is much smaller. As in the US case, once shocks are split into positive and negative, only positive shocks have an impact on industrial production, resulting in a difference in terms of HPDI. In fact, the negative shocks are the ones causing the responses in the linear case to be so small. This is a good example of how splitting the shocks into positive and negative can help us understand what is behind the results in the symmetric case.

Differently, however, the unemployment rate displays no difference. More than that, in this sample, neither positive nor negative shocks seem to have strong effects on the unemployment rate in the euro area. Spreads, on the other hand, are in line with the evidence found for the US, with positive shocks having stronger effects. Once more, the weak effects found in the linear case are caused by the fact that spreads do not react after a loosening in the euro area.

In general, the evidence of asymmetry found in the euro area is very similar to the

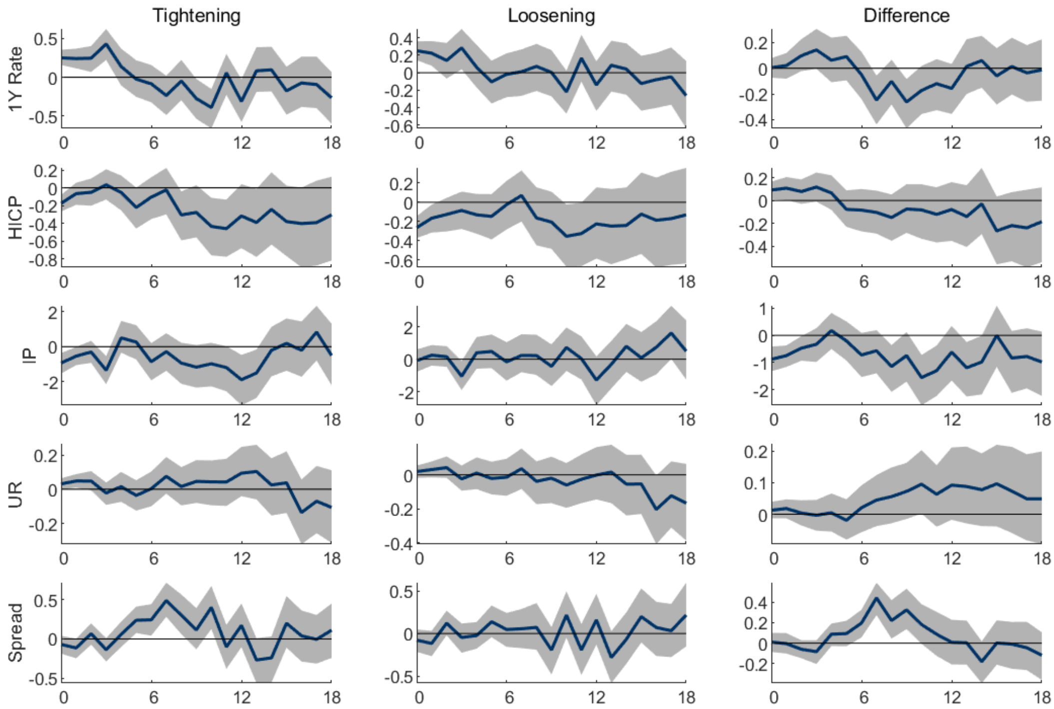

Figure 5: Impulse responses: positive and negative shocks

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The left panel presents impulse responses to positive shocks. The central panel shows the impulse responses to negative shocks. They are flipped to facilitate comparison. The right panel shows their difference. The monetary policy shock has been normalised to have an impact of 25 basis points on the German 1-year rate.

one found in the US. This is relevant because it shows that asymmetric responses are not a particularity of the US and that the predictions of theoretical macro models also find support in the euro area.

6 Conclusion

This paper has investigated whether the effects of monetary tightenings and loosenings on standard macro and financial variables have been asymmetric recently. This is relevant because recent samples may lead to different conclusions for the real variables as reported by Ramey (2016). Moreover, the responses of financial conditions are very important for monetary transmission.

In order to do that, a Bayesian version of the Generalised Least Squares (GLS) procedure proposed by Lusompa (2021) is employed. The LP-IV estimand is then calculated based on the ratio of reduced-form to first-stage coefficients as pointed out by Plagborg-Møller and Wolf (2021). This is suitable because it allows the dynamics to be asymmetric. The use of high-frequency surprises around policy announcements as instruments in the LP-IV approach is important to cope with selection on unobservables, ameliorating the identification problem.

All these advances lead to more refined estimates of the dynamic responses to monetary tightenings and loosenings, which, in turn, can improve the understanding of the transmission of monetary policy. Results show there is evidence of asymmetry for all variables. Industrial production, unemployment, and FCI respond more strongly to positive while CPI responds more weakly to positive shocks, especially at the beginning, possibly due to downward nominal rigidities.

Most importantly, these results show the usual linear impulse responses of industrial production and unemployment rate following monetary policy shocks are driven by contractionary shocks, highlighting the importance of taking into account the direction of the intervention in the study of its effects, with meaningful implications for policy.

The main findings are similar when the non-linear local projections are estimated using a euro area dataset. This is important because it shows that, although the literature on the asymmetry of dynamic responses has focused on the US, the empirical evidence in favour of asymmetry in the dynamic effects of monetary policy is not US-specific.

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Appendix

A. MP Suprises

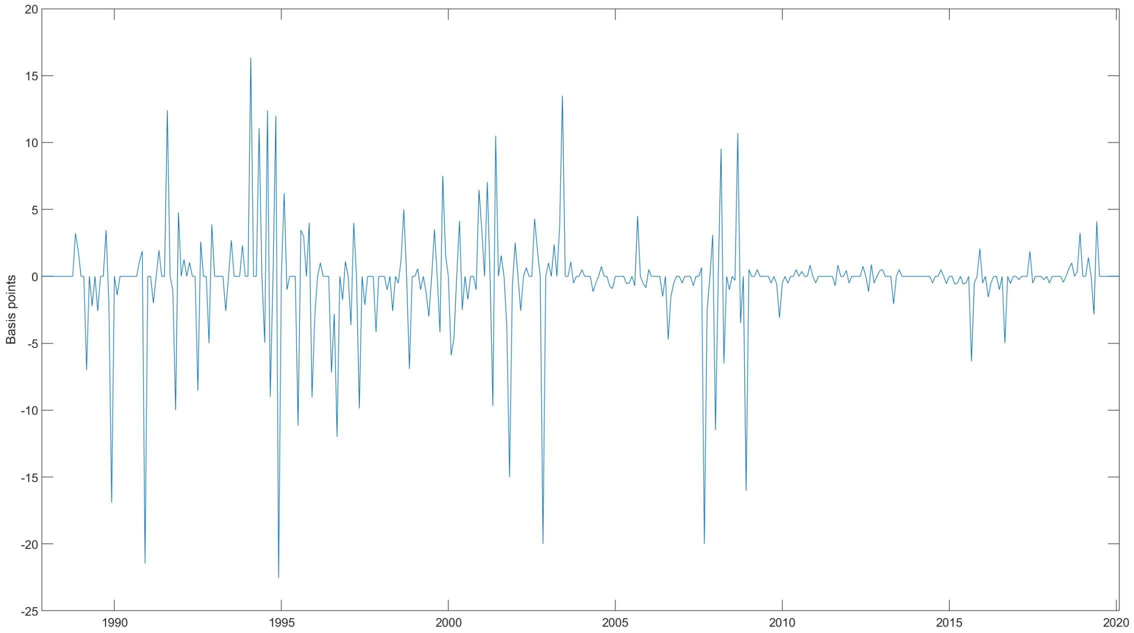

Figure 1: US monetary policy surprises

B. Conjugate Priors and Posteriors

Given a multivariate normal inverse Wishart (NIW) distribution (conjugate prior) of the form NIW$(v_0, \Psi_0, \beta_0, S_0)$:

$$\begin{aligned} \Sigma &\sim IW(S_0, v_0) \\ \beta|\Sigma &\sim \mathcal{N}(\beta_0, \Sigma \otimes \Psi_0) \end{aligned}$$

where S_0 is the prior scale matrix, v_0 the degrees of freedom and Ψ_0 is a diagonal matrix with common elements to all equations.

The posterior distribution over the reduced-form parameters is

NIW$(v_1, \Psi_1, \beta_1, S_1)$:

$$\begin{aligned} \Sigma | y &\sim IW(S_1, v_1) \\ \beta | y, \Sigma &\sim \mathcal{N}(\beta_1, \Sigma \otimes \Psi_1) \end{aligned}$$

where, for the general case:

$$\begin{aligned} v_1 &= v_0 + T \\ \Psi_1 &= (X'X + \Psi_0^{-1})^{-1} \\ \beta_1 &= \Psi_1(X'Y + {\Psi_0}^{-1}\beta_0) \\ S_1 &= Y'Y + S_0 + \beta_0'\Psi_0^{-1}\beta_0 - \beta_1'\Psi_1^{-1}\beta_1 \end{aligned}$$

and, for the flat (Jeffreys) prior, simply:

$$\begin{aligned} v_1 &= T \\ \Psi_1 &= (X'X)^{-1} \\ \beta_1 &= \Psi_1(X'Y) = \hat{\beta}^{OLS} \\ S_1 &= \hat{S}^{OLS} \end{aligned}$$

$$\begin{aligned} v_1 &= T \\ \Psi_1 &= (X'X)^{-1} \\ \beta_1 &= \Psi_1(X'\tilde{Y}) = \hat{\beta}^{GLS} \\ S_1 &= \hat{S}^{GLS} \end{aligned}$$

according to the horizon.

C. Robustness

i. No lags of the proxy

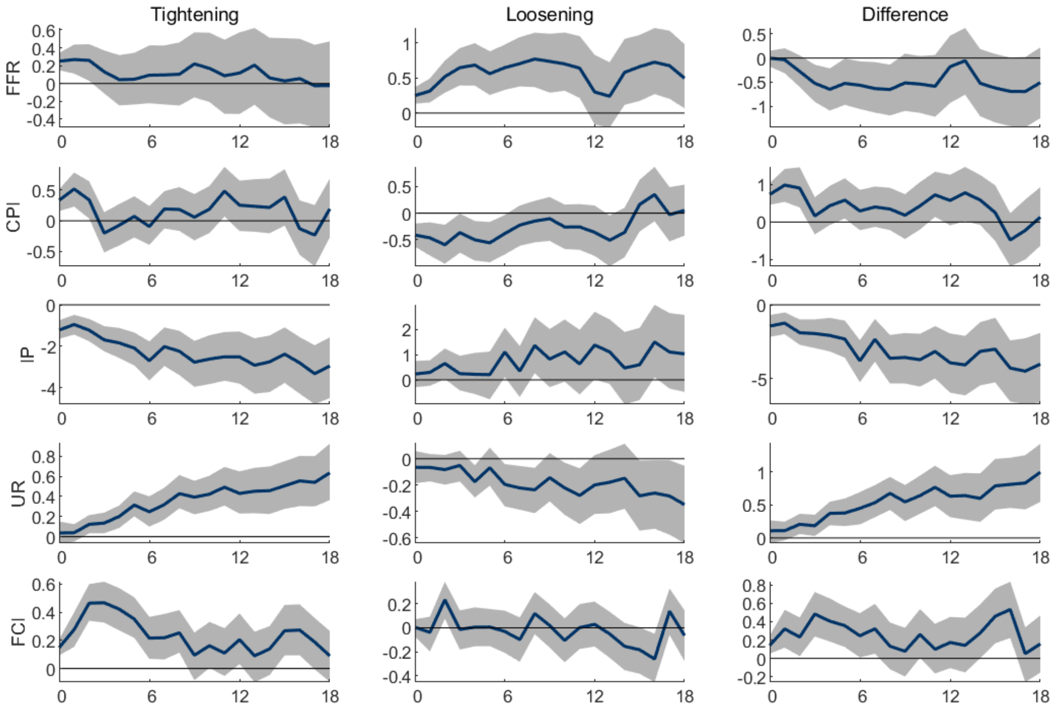

Figure 2: Impulse responses: positive and negative shocks

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The left panel presents impulse responses to positive shocks. The central panel shows the impulse responses to negative shocks. They are flipped to facilitate comparison. The right panel shows their difference. The monetary policy shock has been normalised to have an impact of 25 basis points on the federal funds rate.

ii. Pre-ZLB: 1987M11-2007M12

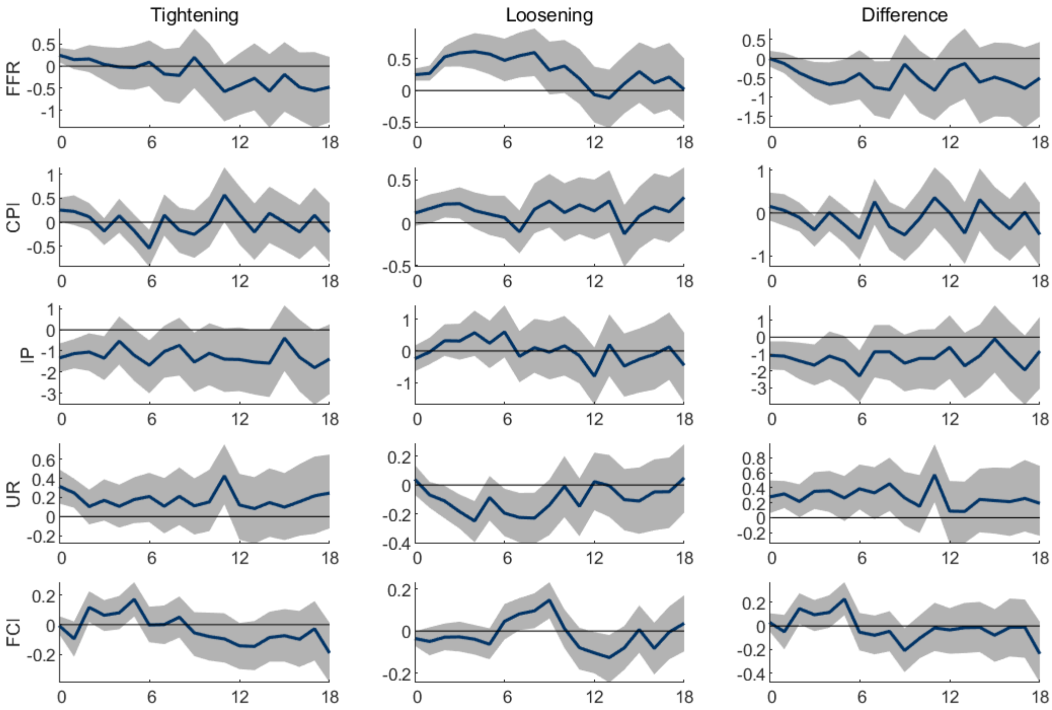

Figure 3: Impulse responses: positive and negative shocks

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The left panel presents impulse responses to positive shocks. The central panel shows the impulse responses to negative shocks. They are flipped to facilitate comparison. The right panel shows their difference. The monetary policy shock has been normalised to have an impact of 25 basis points on the federal funds rate.

iii. Swanson's factors

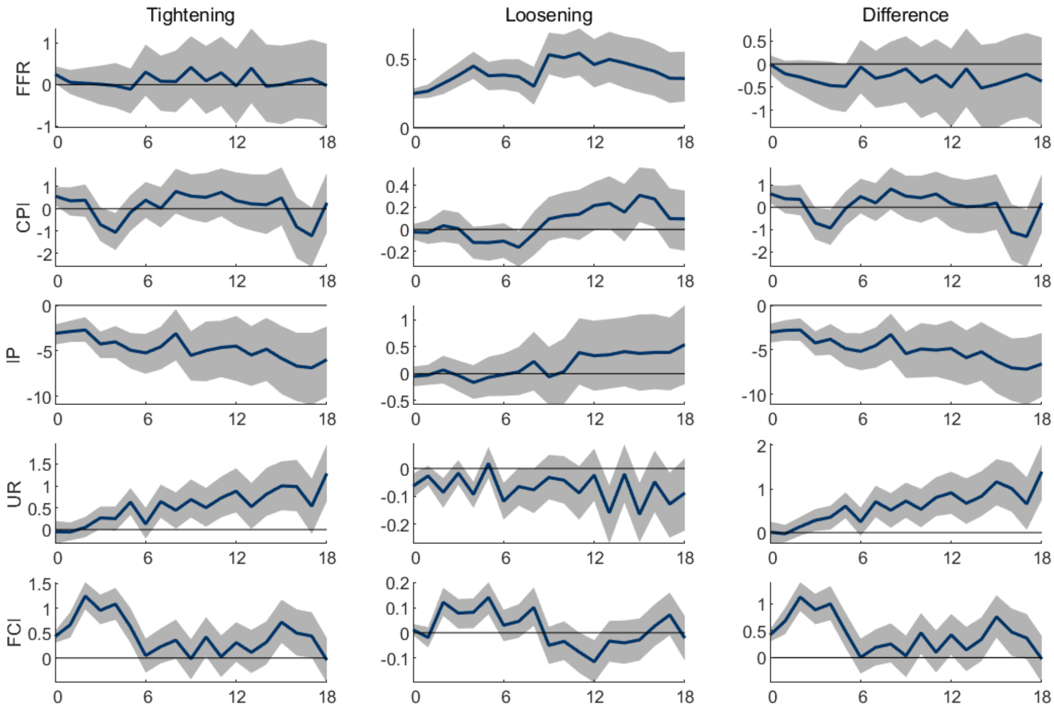

Figure 4: Impulse responses: positive and negative shocks

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The left panel presents impulse responses to positive shocks. The central panel shows the impulse responses to negative shocks. They are flipped to facilitate comparison. The right panel shows their difference. The monetary policy shock has been normalised to have an impact of 25 basis points on the federal funds rate.

iv. BAA spread

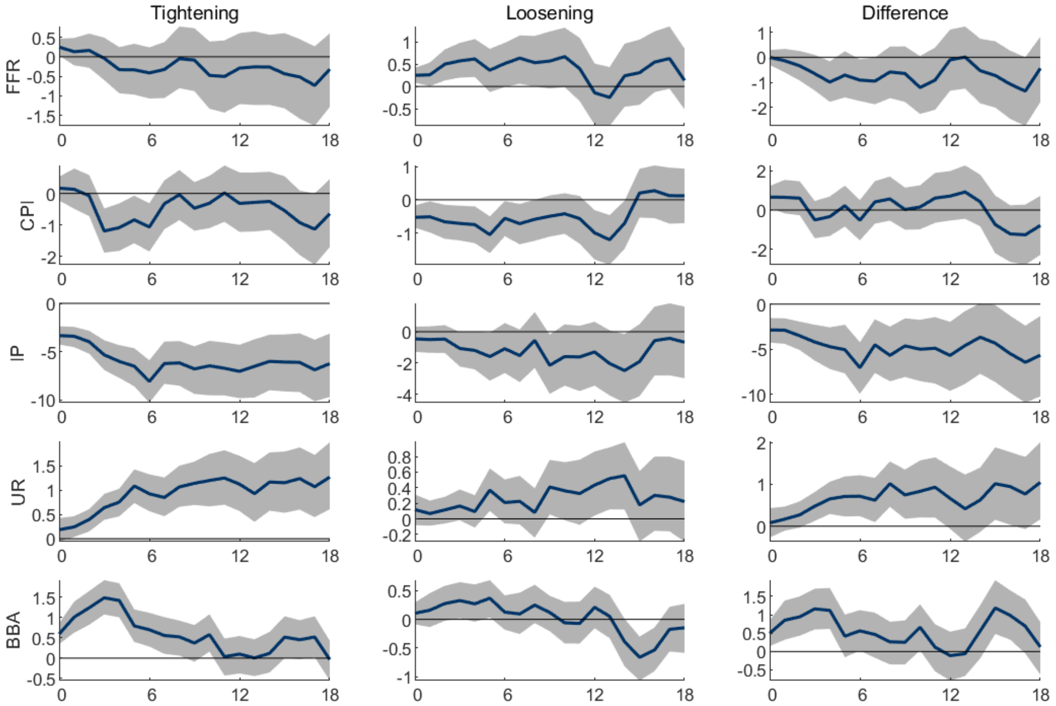

Figure 5: Impulse responses: positive and negative shocks

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The left panel presents impulse responses to positive shocks. The central panel shows the impulse responses to negative shocks. They are flipped to facilitate comparison. The right panel shows their difference. The monetary policy shock has been normalised to have an impact of 25 basis points on the federal funds rate.

v. Excess bond premium

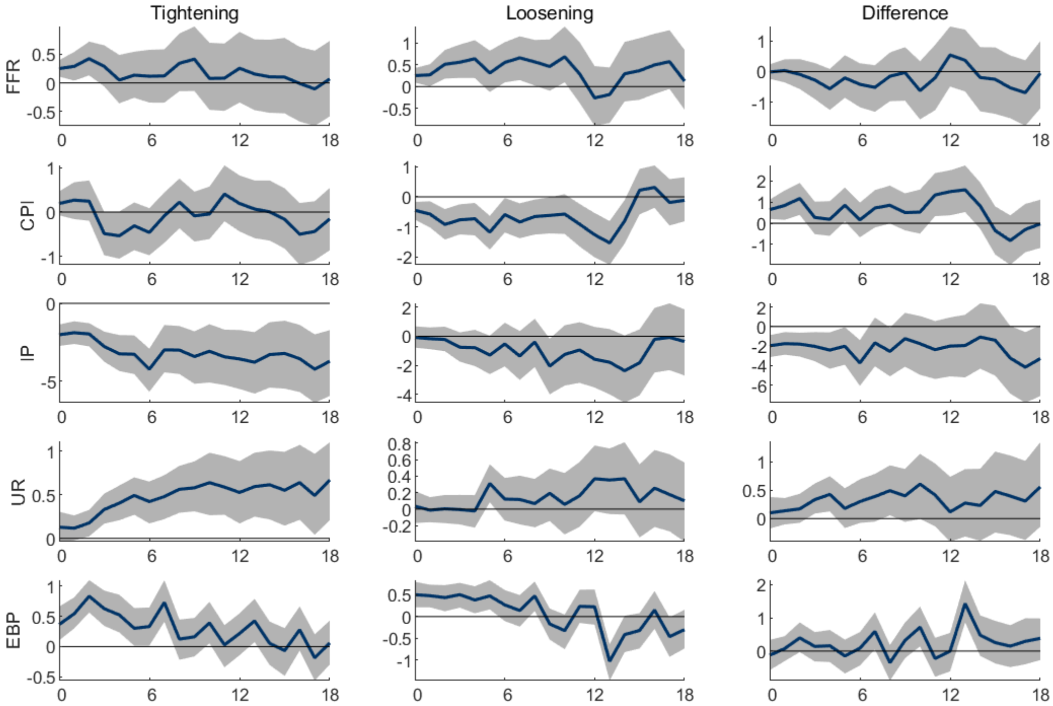

Figure 6: Impulse responses: positive and negative shocks

Notes: The shaded area represents the 68 percent HPD credible sets, and the blue line represents the median. The left panel presents impulse responses to positive shocks. The central panel shows the impulse responses to negative shocks. They are flipped to facilitate comparison. The right panel shows their difference. The monetary policy shock has been normalised to have an impact of 25 basis points on the federal funds rate.

D. Euro area

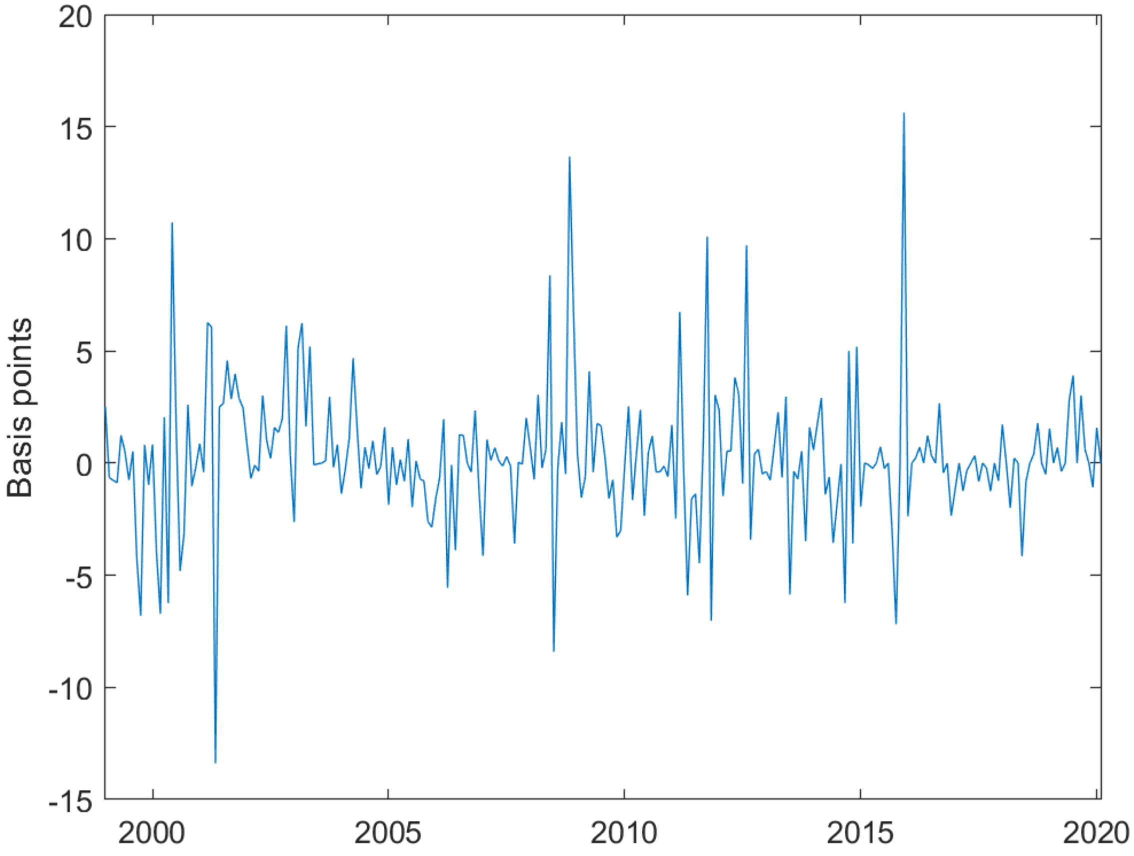

Figure 7: Updated Jarociński and Karadi (2020)'s MP shocks