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Decomposing the monetary policy multiplier*

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Abstract

Financial markets play an important role in generating monetary policy transmission asymmetries in the US. Credit spreads only adjust to unexpected increases in interest rates, causing output and prices to respond more to a monetary tightening than to an expansion. At a one year horizon, the 'financial multiplier' of monetary policy—defined as the ratio between the cumulative responses of employment and credit spreads—is zero for a monetary expansion, -2 for a monetary tightening, and -4 for a monetary tightening that takes place under strained credit market conditions. These results have important policy implications: the central bank may inadvertently over-tighten in times of financial uncertainty.

JEL: C13, C32, E32, E52

Keywords: Monetary policy, credit spreads, local projections, Kitagawa decomposition

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1 Introduction

Financial markets are an important component of the transmission mechanism of monetary policy (see, e.g. Gertler and Karadi, 2015; Caldara and Herbst, 2019). Moreover, recent research has found that monetary shocks affect economic outcomes differently depending on the nature of the intervention and the state of the business cycle (see, e.g. Tenreyro and Thwaites, 2016; Angrist, Jordà, and Kuersteiner, 2018). In this paper we show that financial markets can attenuate or amplify monetary policy, thus generating asymmetries in macroeconomic outcomes like those reported in the literature.

The empirical analysis takes advantage of several novel econometric methods. First, monetary policy shocks are based on recent work by Jarociński and Karadi (2020). Second, to allow for potential asymmetries, we decompose the response of economic outcomes to these shocks using the Kitagawa decomposition (Kitagawa, 1955; Blinder, 1973; Oaxaca, 1973) using local projections as shown in Cloyne, Jordà, and Taylor (2020). Stratification with credit spreads turns out to play an important role in this decomposition and thus in explaining the asymmetries that we observe. Finally, since an impulse response of an outcome to an intervention reflects the implicit *treatment plan* generated by the intervention on the policy variable, we calculate state-contingent monetary multipliers that depend on financial conditions. Inspired by the literature on fiscal policy (see, e.g. Mountford and Uhlig, 2009; Ramey, 2011, 2019), we compute the average effect of a monetary intervention by taking the ratio of the cumulative output response to the cumulative monetary response. This *financial conditions* multiplier, or FCM, allows us to gauge how successful the Fed is in influencing the economy by shifting the actual funding costs of US firms and households rather than by just considering changes in risk-free interest rates and the subsequent term structure response.

The analysis delivers three main results. First, monetary policy affects asset prices, output, and inflation asymmetrically. In addition, the excess bond premium (Gilchrist and Zakrajsek, 2012) only responds to monetary tightening but not to loosening. We find similar asymmetries for the S&P500 stock price index, the VIX index, and the composite Chicago Fed Financial Conditions Index. Second, the interaction between monetary shocks and credit spreads is critical to understand these dynamic responses. The financial response to a shock can greatly amplify (or completely neutralize) the direct impact of interest rates on economic activity. Third, the FCM is large and negative for monetary tightening, but it is close to zero for monetary expansions. In other words, credit markets respond quickly to unexpected increases in interest rates, but generally fail to pass on monetary stimulus to the real economy. The implications of these results are pivotal for central banks as we discuss below.

Related literature Our work is related to two broad strands of the literature. The first one examines the relationship between financial markets and the real economy. Macroeconomic models with financial frictions suggest that leverage constraints can greatly amplify the propagation of real and financial shocks, with potentially dramatic implications for the economy (Mendoza, 2010, He and Krishnamurthy, 2012, Brunnermeier and Sannikov, 2014, Akinci and Queralto, 2021, Akinci, Benigno, Del Negro, and Queralto, 2020). A number of empirical studies have corroborated these models' findings (see, e.g. Jordà, Schularick, and Taylor, 2015, 2016). These studies show that transitions between good and bad financial regimes are important to explain or predict the dynamics of the US economy (Hubrich and Tetlow, 2015, Alessandri and Mumtaz, 2017, Adrian, Boyarchenko, and Giannone, 2019).[1] Our analysis suggests that, because of the nonlinear nature of macro-financial linkages, financial markets are also responsible for the asymmetric propagation of monetary policy shocks.

The second strand of the literature related to out paper studies the transmission of monetary policy. Despite the lack of agreement on the overall importance of monetary shocks (see e.g Ramey, 2016), recent contributions consistently indicate that the interaction between monetary authorities and financial markets is central to the transmission mechanism (see, e.g. Gertler and Karadi, 2015; Caldara and Herbst, 2019). We study this issue using a novel empirical setup that is specifically designed to isolate the (changing) influence of financial markets on the transmission mechanism. Our Kitagawa decomposition of local projections allows us to estimate impulse-response functions by conditioning on both the sign of the monetary surprise and the magnitude of the financial market reaction to it, thus fully mapping out the influence of financial conditions on the

[1]We revisit this evidence in Section 2 showing that credit spreads are a stronger predictor of output and employment levels in bad times—i.e. when they increase—than in good times.

propagation of the shocks. We use the shocks identified by Jarociński and Karadi (2020) to avoid any confusion between the actual policy interventions and the information disclosed by the Fed's actions (see also Miranda-Agrippino and Ricco, 2021), and include in the models a rich set of financial indicators to control for the Fed's response to changes in financial conditions (Caldara and Herbst, 2019).

Other authors have looked at monetary policy non-linearities studying the differences between booms and recessions (Santoro, Petrella, Pfajfar, and Gaffeo, 2014; Tenreyro and Thwaites, 2016) or between monetary expansions and contractions (Angrist, Jordà, and Kuersteiner, 2018; Barnichon and Matthes, 2018). Our contribution is to focus specifically on the role of credit markets and financial frictions. Our results are consistent with the sign asymmetry documented by Angrist, Jordà, and Kuersteiner (2018), Barnichon and Matthes (2018) and Mumtaz and Piffer (2022), and highlight a specific structural mechanism that can account for the stronger impact of monetary tightenings in periods of financial distress.

From a methodological perspective, we combine the insights by Cloyne, Jordà, and Taylor (2020) and Gonçalves, Herrera, Kilian, and Pesavento (2021) to estimate regressions that allow us to make causal statements on the financial side of the monetary transmission mechanism accounting for asymmetries in the propagation of the shocks. Finally, with the FCMs we bring into the monetary policy field tools that are routinely used to analyze fiscal policy interventions (see e.g. Auerbach and Gorodnichenko, 2013, and Ramey and Zubairy, 2018).

The remainder of the paper is organized as follows. Section 2 motivates the analysis showing preliminary evidence on the relation between monetary surprises, financial conditions and economic activity. Section 3 illustrates the empirical framework. Section 4 and 5 discuss our main results. Section 6 examines robustness checks and extensions. In section 7 we present additional results on the role of household credit. Section 8 relates the empirical evidence to the implications of macroeconomic models with financial frictions. Section 9 concludes.

2 Motivating evidence

We begin by examining the dynamic relation between monetary surprises, credit conditions and economic activity through a set of deliberately simple regression models. We emphasize that these regressions do not describe the complex causal links that connect these variables: their objective is simply to put together a set of 'stylized facts' that motivate the more formal analysis carried out in the remainder of the paper.[2]

Credit spreads and economic activity. Consider first a predictive regression in the spirit of *e.g.* Gilchrist and Zakrajsek (2012), but augmented with an asymmetric spread term:

$$y_{t+h} - y_{t-1} = \Delta_h Y_{t+h} = a(L)\Delta Y_t + \beta' Z_t + \delta EBP_t + \delta^+ EBP_t^+ + \epsilon_{t+h}. \tag{1}$$

Since the regression includes spreads in *levels*, rather than changes, we include an asymmetric term EBP^+ that is defined via a *local peak* function:

$$EBP_t^+(j) = EBP_t \, \mathcal{I}\{EBP_t > max(EBP_{t-1,t-2,...,t-j})\}.$$

Intuitively, this term allows the relation to become stronger when EBP has risen continuously for j periods and/or has received a large positive shock.[3] The additional controls Z_t include term spread, stock prices, the fed funds rate, and the systematic (endogenous) component of corporate bond spreads. The results are reported in Table 1. The predictive relation is extremely asymmetric, with an EBP coefficient that roughly doubles when spreads are on the rise. This result simply confirms the nonlinear nature of the nexus between financial and real economy documented e.g. in Hubrich and Tetlow (2015), Alessandri and Mumtaz (2017), Adrian, Boyarchenko, and Giannone (2019) and Akinci, Benigno, Del Negro, and Queralto (2020).

Monetary shocks and economic activity. As a second step we check for asymmetries in the overall impact of monetary policy surprises on economic activity. To do so we estimate asymmetric local projection models using the monetary policy surprise series

[2] We focus for brevity mainly on the Excess Bond Premium (EBP), but the results below hold for a number of alternative proxies of financial conditions (see Section 6).

[3] The behavior of the nonlinear term is shown in Figure A.1 of the annex.

by Jarociński and Karadi (2020), and distinguishing between negative and positive (i.e. expansionary and contractionary) shocks. To capture economic activity we employ alternatively the (log) industrial production, (log) employment or the unemployment rate. The results are reported in Table 2. The estimates confirm the existence of a sign asymmetry in the transmission of monetary shocks: on average monetary restrictions have a far stronger impact on output and employment. [4] The table focuses on 12-month-ahead projections, but the difference between positive and negative shocks is extremely stable across horizons. The results corroborate the conclusions of Angrist, Jordà, and Kuersteiner (2018).

Monetary shocks and credit spreads. The third and final step consists of estimating an analogous set of local projections using as dependent variable a proxy of financial conditions rather than economic activity. As Table 3 demonstrates, the asymmetry shows up in this setup too: monetary restrictions have a stronger impact on bond spreads, measured either by EBP or by a simpler BAA credit spread, and on the S&P500 stock return. This finding is novel in the monetary policy literature, but it is consistent with the idea that financial investors respond asymmetrically to good and bad news (Beber and Brandt, 2010; Veronesi, 1999).

The evidence confirms that credit spreads co-move with output mostly or only when they rise, and it suggests that monetary surprises have an asymmetric effect on financial markets and risk appetite as well as output and employment. Hence, the data is consistent with the possibility that financial markets play some role in rendering the economy more sensitive to monetary restrictions than to monetary expansions. However, a number of difficulties arise in validating this conjecture. The EBP regressions in Table 1 are obviously reduced-form and hence not causal in any sense. The regressions in Table 2 and Table 3 do have a causal interpretation, but they state that monetary shocks affect *both* output and financial conditions, not that they affect output *via* changes in financial conditions. Finally, even if financial conditions matter on average for the transmission of the shocks, the sign asymmetry could potentially arise from completely different mechanisms (see Section 1). In principle, credit spreads could respond more to monetary

[4] The impulse-responses are calculated following (Gonçalves, Herrera, Kilian, and Pesavento, 2021) – see Section 3 for details.

restrictions simply because investors know that these have (for unrelated reasons) a disproportionately large effect on future output. The empirical strategy discussed in Section 3 is designed to bypass these difficulties. [5]

3 Empirical framework

The objective of this paper is to isolate the role of financial markets within the monetary policy transmission mechanism and test whether credit frictions are (partly or entirely) responsible for the asymmetric impact of monetary shocks documented in the literature. This test requires an empirical framework with two key characteristics. One is the flexibility to accommodate the sign asymmetry by allowing the impulse-response functions to differ for positive and negative shocks. The other one is the capability to isolate the causal role played by credit spreads within the transmission mechanism. We discuss these issues in turn below, and then formalize and motivate our notion of a 'financial condition multiplier' for monetary policy. [6]

Impulse Responses with non-linear regressors. The analysis of empirical structural models that allow for a differential impact of positive and negative shocks involve non-trivial technical complications (Kilian and Vigfusson, 2017). Popular solutions are either cumbersome, as they require to compute impulse response functions via Monte-Carlo integration (Koop, Pesaran, and Potter, 1996), or overly restrictive, as they require a tightly parametrized functional form that approximates the non-linear impulse response function (Barnichon and Matthes, 2018). Since the seminal work by Jordà (2005), local projections (LPs) have also emerged as a computationally attractive option for entertaining non-linear dynamics in the transmission of shocks. LPs can deal with interaction terms and indicator functions that can be used to model heterogeneity in the response of economic outcomes to shocks with specifications that nevertheless

[5] Another weakness of Table 2 and Table 3 is that they implicitly treat the regression coefficients as impulse-response functions. This equivalence breaks down in models that include nonlinear regressors: the methodology devised by Gonçalves, Herrera, Kilian, and Pesavento (2021) used in the rest of the paper addresses this issue.

[6] We do not deal with the identification problem, and rely throughout the paper on the monetary shocks estimated by Jarociński and Karadi (2020). Robustness checks conducted using the shocks of Miranda-Agrippino and Ricco (2021) confirm the main results of the analysis.

remain linear in the parameters. In this spirit, for instance, LPs are used by Tenreyro and Thwaites (2016) and Ramey and Zubairy (2018) to study the macroeconomic effects of monetary and fiscal shocks in booms and recessions. This approach has recently come under scrutiny. In particular, Gonçalves, Herrera, Kilian, and Pesavento (2021) analyze in depth the estimation of impulse responses in general structural dynamic models that involve non-linear regressors and conclude that, in this setting, conventional LP estimators are inconsistent. As an alternative, they propose a simple plug-in LP estimator that takes into account the non-linearity of the regressors while achieving consistency at no additional computational cost.

This estimator constitutes our workhorse empirical model. In particular, we specify a response model of the following type:

$$\Delta_h y_{t+h} = \alpha_h MP_t + \alpha_h^+ MP_t \times I(MP_t > 0) + \beta_h(L)'X_{t-1} + \eta_{t,h}, \tag{2}$$

where y is the endogenous variable of interest, MP is an exogenous monetary policy shock series, and X is a set of control variables. The non-linear term $MP_t \times I(MP_t > 0)$ introduces differential effects for negative (expansionary) and positive (contractionary) MP surprises. Gonçalves, Herrera, Kilian, and Pesavento (2021) propose to estimate the IRF of y to a shock δ at horizon h via the following estimator:

$$IRF_{h,\delta}^{LP} = \alpha_h \delta + \alpha_h^+ E\{(MP_t + \delta)^+ - MP_t^+\}. \tag{3}$$

where $(MP_t + \delta)^+ = (MP_t + \delta) \times I(MP_t + \delta > 0)$ and $MP_t^+ = MP_t \times I(MP_t > 0)$. In finite samples, the expectation term in Equation 3 is estimated by its sample average. The estimator in Equation 3 has two appealing properties. First, it can be constructed directly using the coefficient estimates of model in Equation 2 without the need for Monte Carlo integration. Incidentally, this makes inference via bootstrap sampling straightforward. Second, and crucially for our purpose, through the term $E\{(MP_t + \delta)^+ - MP_t^+\}$ the IRF depends on the *sign* of the shock, i.e. positive and negative values of δ will imply different values for this expectation.[7]

[7]Think for instance of cases where MP_t is negative and therefore $MP_t^+ = 0$. Everything else equal, large positive values of δ increase the chances that the term $(MP_t + \delta)^+ > 0$ and that the non-linearity captured by the term $E\{(MP_t + \delta)^+ - MP_t^+\}$ kicks in. In this vein, this estimator replicates the main features of the

Kitagawa decomposition. The estimator in Equation 3 allows us to make statements about the differential impact of positive and negative monetary policy shocks. Yet we need a more elaborate model, in order to dissect the role of financial markets in the transmission of these shocks. At first sight this looks like a standard instrumental variable (IV) problem. For instance, think of summarizing the state of financial markets via a credit spread and suppose to be interested in the *causal* effects of credit spreads on the real economy. One could then run an LP of output on credit spreads instrumenting the latter with a valid instrument, for instance a sequence of past monetary policy surprises. This is indeed the philosophy behind the estimator developed by Barnichon and Mesters (2020).

Yet this would not tell us how changes in financial market conditions affect the transmission of monetary policy shocks, it would only tell us by how much a change in credit spread (caused by *any* shock) would affect output. To isolate the specific role of financial markets in propagating MP shocks, we resort to the LP extension of the Kitagawa-Oaxaca-Blinder decomposition formalized by Cloyne, Jordà, and Taylor (2020). We consider a richer version of the model in Equation 2 where the monetary shock interacts with the financial condition index. Omitting for simplicity the additional controls, the model is given by:

$$\Delta_h y_{t+h} = \alpha_h MP_t + \alpha_h^+ MP_t^+ + \beta_h MP_t \widehat{EBP_t} + \beta_h^+ MP_t^+ \widehat{EBP_t} + \eta_{t,h}, \tag{4}$$

where $\widehat{EBP_t}$ is the financial indicator in deviation from its sample mean.[8] This interaction term allows the impact of the shock to vary depending on the state of financial markets. In the context of this expanded model, the Gonçalves, Herrera, Kilian, and Pesavento (2021) estimator is given by the following equation:

$$IRF^{LP}_{h,\delta} = \delta(\alpha_h + \beta_h \widehat{EBP}_t) + (\alpha_h^+ + \beta_h^+ \widehat{EBP}_t) E\{(MP_t + \delta)^+ - MP_t^+\} \tag{5}$$

Koop, Pesaran, and Potter (1996) estimator, by making the IRF dependant on the history, size and sign of the shock. Also notice that the linear case obtains under the restriction $\alpha_h^+ = 0$.

[8] The baseline analysis is based on EBP; Section 6 shows that the results hold for a broad set of financial conditions proxies.

Rearranging the terms clarifies the relationship between Equation 5 and Equation 3:

$$\mathrm{IRF}^{LP}_{h,\delta} = \underbrace{\alpha_h \delta + \alpha^+_h E\{(MP_t + \delta)^+ - MP^+_t\}}_{\text{Equation 3}} + \underbrace{\widehat{EBP}_t \left[\beta_h \delta + \beta^+_h E\{(MP_t + \delta)^+ - MP^+_t\}\right]}_{\text{State dependence term}} \tag{6}$$

Equation 6 shows that there are two non-linearities at play. The first one has to do with the fact that the response of y depends on the sign of the shock; the second one with the effect of EBP in mediating the impact of the shock on output. This combination is crucial because our objective is to test the role of EBP in causing the sign asymmetry. The main object of interest is the coefficient β^+_h. This coefficient captures the *extra* asymmetry in the response of output to a monetary policy tightening that is generated by a concomitant tightening (relative to the sample average) of financial market conditions. However, in order to give this IRF a causal interpretation, we need further identification assumptions that allow us to isolate exogenous variation in the states themselves (Cloyne, Jordà, and Taylor, 2020).

Our solution is to instrument the EBP terms in equation Equation 4 with the uncertainty shocks estimated by Segal, Shaliastovich, and Yaron (2015). These shocks have a non-trivial effect on the EBP, but they are uncorrelated with monetary surprises. The first-stage regression includes the same set of controls used in the main local projection model (see again Cloyne, Jordà, and Taylor, 2020). The regression is thus defined by the following equation:

$$EBP_t = \theta UNC_t + \Gamma' X_{t-1} + \omega_{i,t},$$

where UNC_t is the uncertainty shock and X_{t-1} collects the lags of the macroeconomic control variables. The interaction term used in Equation 6 is based on the fitted value from the first-stage regression.

The Financial Conditions Multiplier. In our empirical analysis we borrow from the literature on fiscal policy the idea of quantifying the impact of the shocks through cumulative 'multipliers' rather than with impulse responses. An impulse response inherently captures dynamics generated by subsequent changes in the treatment variable induced by the initial intervention. Using the impulse responses described above, we compute *financial conditions multipliers* defined as follows:

$$FCM_H = \frac{\sum_{h=1}^{H}(\Delta y_{t+h}|MP_t)}{\sum_{h=1}^{H}(\Delta EBP_{t+h}|MP_t)} \tag{7}$$

The FCM is the ratio between the cumulative response of an economic activity indicator (y) over a predefined horizon (H) and the response of a financial conditions proxy (EBP) over the same horizon, conditional on a monetary surprise (MP). The effectiveness of fiscal policy is routinely assessed through multipliers of this kind, which aim to establish whether the overall output response to a given cumulative change in public expenditures is large enough to justify the intervention (see e.g. Auerbach and Gorodnichenko, 2013, and Ramey and Zubairy, 2018).

We argue that a similar logic applies to monetary policy. The post-2008 experience demonstrates that monetary authorities try to control the overall funding costs of the private sector rather than just the yield curve. A large set of unconventional tools can be deployed when short-term rates lose their grip on long-term funding conditions. The FCMs offer a simple metric to assess the policy maker's success in stabilizing prices and output by tilting the overall financing costs faced by households and firms in the economy. The interpretation of the FCMs hinges of course on how the underlying responses are estimated. In particular, one has to identify the causal role of EBP in propagating the original shock in order to read the FCM as a 'multiplier' for monetary policy interventions. In our case, causality is established through the Kitagawa decomposition. We discuss this point extensively in the next two sections.

4 Macro-financial impact of expansions and restrictions

In this section we reassess the influence of monetary shocks on both the financial and the real side of the US economy, focusing specifically on the asymmetric impact of expansions and recessions. Some of our estimates revisit well-known results in the literature. However, the analysis contributes to the debate in two ways. First, we document in more detail the nature of the nonlinearity. We show that the asymmetry is extremely pronounced for the prices of risky assets, such as corporate bonds and equities, that respond sensibly more to monetary restrictions. Second, we provide preliminary evidence that financial markets are pivotal in generating an asymmetric response on the real side of the economy: the 'financial condition multipliers' derived from our regressions are far larger for monetary contractions compared to monetary expansions. The models examined below do not explicitly isolate the financial side of the transmission mechanism, but they are simpler and hence complementary to the Kitagawa decomposition developed in Section 5.

The baseline specification of our local projection model is described by equation Equation 2. The left-hand-side variable is represented alternatively by an economic activity indicator (industrial production, employment, unemployment rate, consumer price index) or by a financial indicator. Our preferred financial condition proxy is the Excess Bond Premium (EBP) by Gilchrist and Zakrajsek (2012); we also report the results for the one-year Treasury bill yield, the S&P500 stock price index and the VIX volatility index, which capture changes in risk appetite and investment flows from a different and somewhat broader perspective.The main regressor is the monetary surprise series constructed by Jarociński and Karadi (2020). We include among the controls two lags of the dependent variable, the 10-year to 3-month Treasury term spread, the S&P500 stock price index, the Fed fund rates, and the systematic component of corporate bond spreads. The estimation sample runs from January 1990 to December 2017. [9]

We start by analyzing a linear version of the model, as in the literature. In computing the impulse responses, we focus throughout on a representative one-standard-deviation monetary surprise, which is associated to a (positive or negative) change of approximately 5 basis points in the three-month fed funds futures rate (see Figure 4 of Jarociński and Karadi, 2020). In the linear model, a monetary restriction causes a drop in output, employment and prices, and an increase in the unemployment rate (see Figure A.2 of the annex). The shock causes industrial production to drop by about 0.2 percentage points and the unemployment rate to rise by 0.05 percentage points in 12 months. It also generates a decline in stock prices and an increase in EBP, Treasury yields and VIX index. All responses are broadly in line with the literature, both qualitatively and quantitatively.

[9] All impulse-response functions are calculated taking into account the Gonçalves, Herrera, Kilian, and Pesavento (2021) correction term – see Equation 3. The standard errors are based on 1000 double-block bootstrap replications.

The nonlinear version of the model allows negative (expansionary) and positive (contractionary) monetary shocks to have different effects. Figure 1 shows the responses obtained in this specification for the economic activity indicators conditioning alternatively on a ± 5 basis points shock. Figure 2 reports the responses of the financial indicators to the same positive and negative shocks. Both figures show the mean responses with 68% and 95% confidence bands. The sign of the responses is in line with the priors: monetary expansions tend to stimulate financial markets and economic activity, while restrictive monetary policy has a negative effect on both. However, the latter is clearly far more powerful. The rise in the unemployment rate at the one-year horizon (which amounts to about 0.2 percentage points) is four times larger than in the linear model. For EBP, the increase (15 basis points) is three times larger than in the linear model. Furthermore, in many cases the response to a monetary loosening is close to zero and not significant from a statistical perspective. The S&P500 stock price index and the VIX index behave roughly like EBP, while the response of 1-year and 10-year Treasury Bill yields is approximately symmetric (see Figure A.3 of the annex). This suggests that the mechanism that generates the asymmetry operates mostly or only through the prices of risky financial assets. We investigate this issue in detail below and in the theoretical analysis of Section 8.

We investigate the relation between real and financial asymmetries, by computing 'financial condition multipliers' (FCMs). FCMs express the ratio of the cumulative output response over the cumulative response of EBP over a given time frame (see Section 3). This gives a rough idea of the shift in economic activity that the Fed can get for a unit change in bond spreads.[10] Figure 3 shows the multipliers obtained at the 12-month horizon for the unemployment rate, industrial production and employment. The first panel shows the results for the linear model. The following two panels replicate the calculation for the nonlinear model, distinguishing between a positive and a negative 5 basis point shock. In all cases the edges of the boxes represent the 5th and 95th percentiles of the bootstrapped distribution of each of these multipliers. The linear estimates indicate that, on average, after a monetary tightening the Fed should expect an increase in the unemployment and a drop in employment and industrial production.

[10] We focus on EBP for brevity: the results are similar for the alternative financial proxies.

However, these average results are heavily driven by restrictive monetary conditions: for all three indicators the multipliers are large and significant after a tightening (middle panel) but smaller and non-significant after an expansion (right panel). This represents a first reality-check for the idea that financial markets may account for the asymmetric response of the real economy to monetary shocks. In essence, the estimates indicate that financial and real indicators move in lockstep, and that the asymmetric response of EBP is *in principle* sufficiently pronounced to explain the asymmetries recorded for unemployment rate, industrial production and employment. However, the estimates are not sufficient to draw this conclusion. There may be mechanisms that contribute to the overall output asymmetry (i.e. the numerator of the FCM), but are unrelated to the behavior of EBP (the denominator of the FCM). In the next section we tackle this problem by studying the propagation of monetary shocks in environments where EBP rises and falls under the influence of independent drivers, namely exogenous changes in risk and uncertainty.

5 Do financial markets cause the asymmetry?

To isolate the causal role of financial markets in propagating monetary shocks (either linearly or non-linearly) we need a slightly more sophisticated regression setup. More specifically, the model should tell us whether the impact of a shock changes when credit conditions turn out to be tight or loose for reasons that are independent of (i.e. exogenous to) the overall evolution of the macroeconomic environment. Intuitively, one needs an interaction between an exogenous monetary shock and an exogenous shift in credit conditions to isolate the specific role of financial markets in the overall transmission mechanism.

Cloyne, Jordà, and Taylor (2020) (CJT) discuss a similar problem in relation to the interaction between fiscal and monetary policy, showing that the impact of a fiscal intervention depends on the response of the monetary authority: the fiscal multiplier is significantly larger if the central bank is unable or unwilling to offset the shock through a change in interest rates. In both cases the propagation of the initial exogenous shock (monetary or fiscal) hinges on the endogenous response of a specific variable (respectively interest rates and credit spreads). Following CJT, we modify our empirical model to calculate a Kitagawa decomposition of the effects of a monetary shock, disentangling the *direct* effect of the shock on output from the *indirect* effects that are transmitted (and potentially amplified) by the change in credit spreads.

We extend the baseline model in two ways. First, we add to the local projection the interaction between monetary shock and credit spread. Second, we instrument the spread to isolate changes in credit conditions that are not driven by generic business cycle perturbations occurring in the same month. Omitting for simplicity the control variables, the expanded regression model takes the following form:

$$\Delta_h y_{i,t+h} = \alpha_h MP_t + \alpha_h^+ MP_t^+ + \beta_h MP_t \widehat{EBP}_t + \beta_h^+ MP_t^+ \widehat{EBP}_t + \eta_{i,t,h} \tag{8}$$

MP^+ isolates, as usual, unexpected monetary contractions. $\widehat{EBP}$ is the fitted value of EBP obtained from a first-stage IV regression where we use as instruments the exogenous uncertainty shocks estimated by Segal, Shaliastovich, and Yaron (2015) (see Section 3). Shocks to risk, uncertainty and/or risk preferences are a good candidate for the first-step regression because they explain a large share of the volatility of EBP and other asset prices. These models include as controls four lags of the dependent variable (alternatively IP, unemployment or employment) and two lags of CPI inflation, one-year T-Bill rates and EBP. Along with the plain regressors X_{t-1} we add a set of interacted regressors $X_{t-1}MP_t$ in order to control for potential 'indirect effects' of monetary shocks that do not specifically depend on the behavior of EBP. [11]

We start again by discussing the responses obtained from a restricted version of the model in Equation 8, where $\alpha^+ = \beta^+ = 0$. This specification allows us to measure the indirect financial effects of a monetary, shock abstracting temporarily from the potential asymmetry of the transmission mechanism. The test is interesting in its own right because, although credit markets are known to respond to monetary shocks, less is known on how their response affects the transmission of the shock to the real economy.[12]

[11] The interactions are based exclusively on the first lag of the controls to save degrees of freedom. The first-stage regression for EBP also includes the controls X_{t-1} that appear in the second-stage local projection model.

[12] Answering this question requires either a Kitagawa decomposition or a counterfactual analysis based

The impulse-response functions are shown in Figure 4. We focus as usual on a monetary restriction that causes a 5 basis points increase in the fed funds future rate. Using Equation 8 we can examine the impact of the shock under alternative financial market scenarios. In particular, we calculate the responses for a grid of 11 evenly-spaced values of EBP in the interval $[\mu - \sigma, \mu + \sigma]$, where μ and σ are mean and standard deviation of the instrumented EBP. Thicker lines correspond to higher EBP values. The monetary tightening has a recessionary impact in all cases, causing a rise in unemployment and a decline in output and employment levels. However, the magnitude of the responses hinges critically on the behavior of the bond market. The overall contraction in industrial production is about -0.6% when EBP is low and it exceeds -1% when EBP is at its upper bound. A similar pattern emerges in the labor market: both employment and the unemployment rate have responses that get significantly larger (smaller) when EBP moves above (below) its mean value.

The next step is to ask whether the propagation mechanism changes depending on the sign of the monetary surprise as well as the behavior of the bond market. Figure 5 shows the impulse-response functions derived from the full nonlinear version of Equation 8. The left column reports the responses of the three economic activity indicators to a monetary tightening (MP^+). The patterns are qualitatively similar to those in Figure 4: the shock causes a slowdown in economic activity, and its impact is (in absolute terms) an increasing function of the bond spread.

Notice that from a quantitative perspective the responses are larger than those obtained from the symmetric model. Under the worst-case EBP scenario, for instance, the final impact of the shock is approximately twice as big for unemployment (+0.8% versus +0.4%) and industrial production (-2% versus -1%) and three times larger for employment (-1.5% versus -0.6%). The reason is that, despite taking into account the interaction between shocks and spreads, the symmetric local projection model implicitly mixes expansionary and restrictionary shocks, thus underestimating the actual impact of a monetary tightening. The right column of Figure 5 depicts the impact of an equally-sized monetary loosening (MP^-). Under tight financial market conditions the expansion

on a fully-fledged structural model. The comparative advantage of our Oaxaca-Blinder approach is its reliance on lighter identification restrictions and a robust semi-parametric regression model.

is followed as expected by a drop in unemployment and a rise in employment and industrial production. However, the responses are far smaller than those caused by a tightening, and they rapidly approach zero when conditioning on low EBP levels. Both the overall impact of the shock and the financial amplification effect are weaker in the case of expansionary monetary policy surprises.

Figure 6 shows the Financial Condition Multipliers (FCMs) estimated by the nonlinear model. We focus for brevity on employment, and report in the annex a similar set of results for industrial production and unemployment rate (see Figure A.4). As in the previous section, the FCMs are computed dividing the cumulative response of the unemployment rate at the 12-month horizon by the EBP response to the same monetary shock over the same horizon. The key difference is that the impulse-response functions account now for the influence of EBP on the transmission of the shock to the real economy (see Section 3). Briefly, we summarize the heterogeneity introduced by the financial mechanism by calculating the multipliers, conditioning alternatively on: (i) EBP being one standard deviation below its historical average (*loose*); (ii) EBP being at its historical average (*neutral*); and (iii) EBP being one standard deviation above its historical average (*tight*). [13] In the case of a monetary contraction, the FCMs differ widely across financial states (left panel). The average multiplier is negative, consistent with Figure 1 and Figure 2, because it combines a positive EBP response and a negative employment response. A low premium can completely undo the impact of the monetary tightening, leaving unemployment unchanged. A high premium greatly amplifies the shock, generating a multiplier that is roughly two times larger than the average. The central estimate implies that, under 'tight' market conditions, the monetary intervention could cause a 4 percentage points drop in employment through a hypothetical 1 percentage point increase in EBP. The multipliers associated to a monetary expansion are both smaller and less dependent on the behavior of the bond market (right panel). In this case the estimates of the FCMs are similar and statistically close to zero across the three scenarios.

[13] Given the design of the regression, the 'neutral' scenario yields the average treatment effect captured by a model that neglects the interaction between shocks and spreads.

6 Robustness and extensions

Measurement. Our findings do not hinge on using EBP as a proxy of financial conditions. In Figure 7 we report a range of FCM estimates based on alternative indicators, focusing again on the 12-month horizon. We calculate the FCMs for combinations (i.e. ratios) of our three activity indicators (unemployment rate, IP, employment) and four financial indicators (the baseline EBP, a BAA spread, the Chicago Fed FCI and the overall Gilchrist-Zakraysek spread). The top line shows that the multipliers associated to a 5 basis points monetary tightening are large and statistically significant in all cases. The bottom line confirms that the multipliers for equally-sized expansions are zero across specifications. After a monetary tightening, the FCMs for the unemployment rate are generally around 0.5, which is consistent with the 'neutral' (i.e. average) estimate reported in Figure 6. The multiplier tends to be larger for FCI than for the three corporate bond spreads, suggesting that banks, money and equity markets also play an active role in the transmission mechanism.

The results are also robust to the design of the first-stage regression in the Kitagawa decomposition of equation (8). In our baseline analysis we instrument EBP using uncertainty shocks. As a simple alternative, we re-estimate the decomposition interacting monetary shocks directly with the actual value of EBP: in this setup 'financial shocks' are implicitly identified as the residuals of the EBP equation in a recursive VAR where financial conditions are ordered first (see Plagborg-Møller and Wolf, 2021), bypassing completely the IV step. Both the sign asymmetry and the influence of EBP turn out to be more pronounced than in our baseline estimates (the results are available upon request).

Identification. Another important question is to what extent the results depend on the specific identification strategy proposed by Jarociński and Karadi (2020). To investigate this issue we replicate the analysis using the monetary shock series estimated by Miranda-Agrippino and Ricco (2021).[14] The results are shown in Figure 8, which adopts

[14] Miranda-Agrippino and Ricco (2021) construct the shock series (MPI_m) by first isolating high-frequency surprises in federal funds futures around FOMC announcements that are orthogonal to Greenbook forecast and forecast revisions, and then averaging these up to the monthly frequency. The procedure represents an alternative way of disentangling true policy shocks from the informational effects associated to the Fed's decisions. We thank Riccardo Degasperi for providing us with shock estimates updated to December 2015.

the same layout as Figure 7. The test confirms the existence of a stark difference between monetary tightenings (top row) and monetary expansions (bottom row), irrespective of how we measure economic activity and/or financial market conditions.

State *versus* sign dependence. A third conceptual problem we deal with is the relation (and potential confusion) between sign and state dependence. Past research highlighted important differences in the transmission of monetary shocks in booms and recessions.[15] Is the sign asymmetry simply state dependence in disguise? As a preliminary test, in Figure A.5 of the annex we report the empirical distributions of the Jarociński and Karadi (2020) shock obtained conditioning on various indicators of the state of the business cycle. We discriminate *inter alia* among phases of positive/negative IP growth, above-/below-median unemployment rate levels, positively/negatively-sloped yield curve as well as the absolute levels of FCI, VXO, EBP or the Michigan Consumer Sentiment index. In most of these cases the conditional densities turn out to be very similar across subsamples. The only exception is IP growth: in this case the left tail of the shock distributon is thicker in 'bad times' (large expansions tend to take place during economic contractions), and a formal Kolmogorov-Smirnov test rejects at the 5% level the null hypothesis that the distributions are the same across subsamples. [16]

The overlap between economic contractions and monetary expansions renders the separation of state- and sign-dependencies intrinsically difficult. Nevertheless, we find that the sign asymmetry shows up clearly even if economic contractions are excluded from the sample. In Figure 9 we report a set of multipliers obtained by re-estimating our local projections using only periods of positive annual growth in industrial production. Estimates of FCMs vary more across indicators, and their statistical significance is weaker than in the full-sample estimation. However, monetary restrictions still cause larger responses than monetary expansions. As in the baseline case, both output and financial condition indicators – *i.e.* numerator and denominator of the FCM – respond strongly to a contraction and are virtually unaffected by an expansion (see Figure A.7).

[15] Santoro, Petrella, Pfajfar, and Gaffeo (2014), Tenreyro and Thwaites (2016).

[16] The finding is in line with Tenreyro and Thwaites (2016), who show that the distribution of the monetary shocks used in their analysis (which are residuals from an estimated reaction function à la Romer and Romer, 2004) has a thick left tail that includes mostly negative (i.e. expansionary) policy surprises.

7 Household finance

Household credit differs from firm credit along many dimensions. It consists of bank loans rather than bonds, and it funds very different types of expenditure (consumption goods or housing versus capital). Despite these differences, the mechanisms examined in the previous sections also operate on the household side of the credit market: like firm credit, household credit responds asymmetrically to monetary policy, playing an active role in rendering the overall transmission mechanism asymmetric.

Figure 10 shows the impact of monetary shocks on (i) the spread between 30-year mortgage rates and Treasury securities (*Mspread*) and (ii) the aggregate mortgage-to-GDP ratio in the US (*HHMtoGDP*).[17] *Mspread* is a rough household-side counterpart of EBP, while *HHMtoGDP* provides a balance-sheet based proxy of household leverage. The responses are estimated using local projections that are virtually identical to those used in Section 4: the only difference is the dependent variable, whose lags are also included among the controls.

There is a marked asymmetry between restrictions, that cause a large increase in spreads and a drop in the mortgage-to-GDP ratio, and expansions, that have a small and often less significant impact on both variables.

In Figure 11 we show estimates of sign- and state-dependent monetary policy multipliers based on mortgage spreads instead of EBP. The estimation follows again Section 5: we instrument *Mspread* using uncertainty shocks, and then interact the instrumented spread with MP shocks in a Kitagawa decomposition based on Equation 8. The similarity with Figure 6 is striking: monetary contractions cause a sizable drop in employment, particularly under tight mortgage market conditions (i.e. a high *Mspread*), whereas monetary expansions have a null multiplier.

These results show that monetary shocks propagate asymmetrically through most if not all major credit markets, suggesting that (i) something in the credit intermediation process renders the transmission intrinsically asymmetric, and (ii) this mechanism is

[17] *Mspread* is the spread between 30-year fixed rate mortgages and the yield on 30-year constant maturity Treasury Securities at 30-Year Constant Maturity (a monthly average of the weekly series available from the St. Louis FRED database). *HHMtoGDP* is the ratio of total mortgages to GDP (also from FRED): the quarterly data is interpolated to the monthly frequency using a cubic spline that preserves the end-of-quarter values of the original series.

general enough to show up for both bond and bank finance. In the next section we show that the presence of leveraged intermediaries at the center of the intermediation chain is sufficient to generate the patterns observed in the data.

8 Leverage constraints and monetary asymmetries

Our empirical results can be easily rationalized considering the interplay between interest rates, leverage and credit spreads in the economy. A large fraction of the debt and equity issued by non-financial firms is typically held by leveraged investors. In an unconstrained world, these investors would respond symmetrically to monetary shocks. In reality, they are likely to be more sensitive to monetary restrictions that raise their funding costs and push them closer to their borrowing limits, forcing them to shrink their balance sheets. The deleveraging process and 'fire sales' originating from this adjustment can in turn have important implications for the real economy. A similar asymmetry can in principle arise for bank lending; the leverage and portfolio allocation of commercial banks are indeed subject to a range of regulatory constraints that explicitly demand a reduction in the size/riskiness of the balance sheet after an adverse shock.

To illustrate these points we resort to the model developed by Gertler and Karadi (2011). In the model, financial intermediaries ('banks' for short) channel funds from savers to entrepreneurs, and are subject to an agency problem arising from their ability to divert the funds they receive. An endogenous leverage constraint arises, as banks can only operate if their internal equity (the banks' franchise value) is sufficiently high to insure that no diversion takes place. Gertler and Karadi (2011) study a linear version of the model in which the constraint binds at all times — i.e. the financial sector always operates at its maximum capacity. We relax this assumption and consider the case where the leverage constraint binds in equilibrium, but exogenous shocks can temporarily push banks to operate with spare capacity. [18] We stick to the original calibration of the model based on pre-2007 US data, with a steady-state loan spread of 100 basis points and a leverage ratio of four.[19] Figure 12 summarizes the dynamics triggered by monetary

[18] We solve the model using a first order piece-wise approximation around the steady state, as in Guerrieri and Iacoviello (2015). The solution is based on the RISE toolbox documented in Maih (2015) (see Bjørnland, Larsen, and Maih (2018) for a recent application).

[19] Investment banks had leverage ratios above 20 before the global financial crisis, but the calibration is

policy shocks. The shocks are normalized to deliver a 50 basis points increase or decrease in short-term interest rates. If leverage constraints bind at all times, the responses are symmetric by construction (continuous lines). The comovement between interest rates (bottom left panel) and the loan premium (top right panel) is a trademark of the financial accelerator: by reducing firms' investment, a rate rise generates a decline in asset prices that causes a deterioration in bank balance sheets, an increase in the premium and a further reduction in investment. With occasionally binding constraints, monetary expansions have a far smaller impact on both real and financial variables (dashed lines). The reason is that the responses of both loan spreads and bank leverage are muted. The economy behaves almost as if it was unconstrained, and the disappearance of the 'financial acceleration' effect implies that the increase in investment and output (and to a lesser extent inflation) are much smaller than in the previous case.

A few comments are in order. First, the exercise is purely qualitative. Our solution method (a piece-wise approximation around the binding equilibrium) could inflate the magnitude of the nonlinearity, for instance, while the relatively low steady-state leverage used in the simulation may potentially reduce it. Second, asymmetries of this kind are common to a large class of general equilibrium models with borrowing constraints (see *e.g.* Guerrieri and Iacoviello, 2017). The Gertler and Karadi (2011) setup seems particularly suited to rationalizing our results because monetary surprises have a strong impact on asset prices, which means that the interplay between interest rates and loan spreads lies at the heart of the transmission mechanism. However, alternative microfoundations may in principle generate similar results. Third, there are many mechanisms that could reinforce the basic leverage effect explored in this exercise. Proximity to the zero lower bound may render monetary expansions less effective, either *ex post* or in expected terms. And even investors that have no leverage at all may rationally react more to 'bad news' in order to hedge against future market volatility (see, e.g. Veronesi, 1999).

meant to capture the aggregate behavior of the many financial and non-financial entities that invested actively in US financial markets (see Gertler and Karadi, 2011).

9 Conclusions

This paper studies the influence of financial markets on the transmission mechanism of monetary policy. As a first pass, we show that market investors are more sensitive to monetary contractions than to monetary expansions, and that this asymmetry is broadly consistent with the stronger impact that restrictions have on economic activity in the US. However, to investigate the mechanism in greater detail, we estimate local projection models where monetary shocks and credit spreads interact with one another. We then develop a Kitagawa decomposition to check how the propagation of a shock changes depending on the degree of financial market uncertainty, and calculate 'financial condition multipliers' that show how a given shock affects output and employment through changes in financial conditions. The analysis suggests that bond spreads and asset prices only respond to unexpected monetary restrictions, and that the interaction between the monetary shock and the response of financial markets to this shock is critical in generating the sign asymmetry: on average, the FCM is large and negative for a monetary tightening and close to zero for a monetary expansion. Our results highlight the difficulties that central banks face when tightening interest rates during periods of high uncertainty in financial markets. Higher uncertainty greatly accentuates the effects of contractionary monetary policy relative to periods of more normal financial conditions.

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	URATE_{t+12}	IP_{t+12}	EMP_{t+12}
EBP_t	**0.21**	**-0.14**	**-0.18**
p-value	*0.00*	*0.03*	*0.00*
EBP^+_t	**0.20**	**-0.17**	-0.14
p-value	*0.03*	*0.00*	*0.13*
Adjusted R^2	0.47	0.40	0.58

Table 1: Asymmetric predictive power of EBP for economic activity. EBP^+ is the net increase in the Excess Bond Premium, defined using a local peak function as described in the main text. All regressions include as additional controls 10-year to 3-month Treasury term spread, S&P500 stock price index, Fed fund rates, and the systematic component of corporate bond spreads. The sample is January 1990-March 2019.

	URATE_{t+12}	IP_{t+12}	EMP_{t+12}
MPShock^-	-0.01	0.02	0.01
CI	[-0.02,0]	[-0.05,0.1]	[-0.02,0.03]
MPShock^+	**0.11**	**-0.35**	**-0.13**
CI	[0.06,0.15]	[-0.57,-0.1]	[-0.19,-0.05]

Table 2: Asymmetric response of economic activity to monetary surprises. $\text{MPShock}^{+(-)}$ is the series of contractionary (expansionary) monetary suprises estimated by Jarociński and Karadi (2020). All regressions include as additional controls 10-year to 3-month Treasury term spread, S&P500 stock price index, Fed fund rates, and the systematic component of corporate bond spreads. Standard errors based on 1000 double block bootstrap replications. CI refers to a 95% confidence interval. The sample is January 1990-December 2017.

	EBP_{t+12}	BAA_{t+12}	SP500_{t+12}
MPShock^-	**-0.03**	**-0.03**	0.56
CI	[-0.04,-0.01]	[-0.05,-0.02]	[-0.05,1.11]
MPShock^+	**0.13**	**0.14**	**-3.05**
CI	[0.05,0.22]	[0.06,0.2]	[-4.62,-1.18]

Table 3: Asymmetric response of the Excess Bond Premium to monetary surprises. See notes to Table 2.

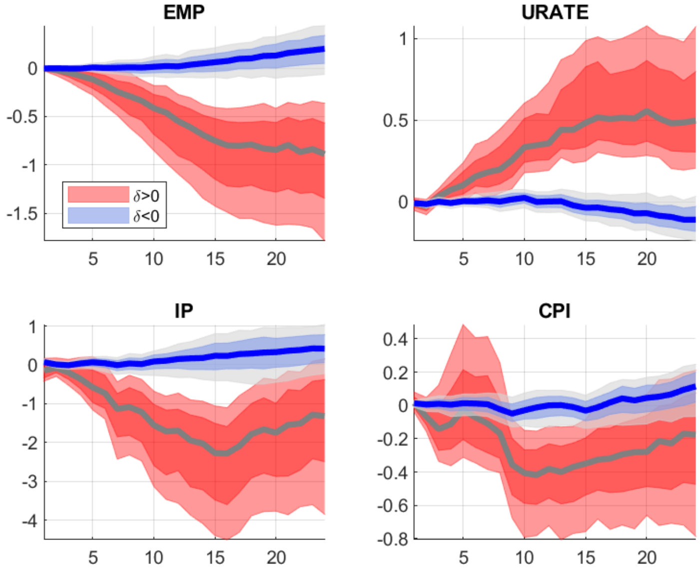

Figure 1: Asymmetric impact of monetary surprises on Economic Activity.
Response of economic activity to expansionary (blue) and contractionary (red) monetary policy shocks. The shock series comes from Jarociński and Karadi (2020). The size of the shock is normalized to 5 basis points; the responses to an expansionary shock are multiplied by minus one to facilitate the comparisons. All responses are obtained from asymmetric local projection models, controlling for two lags of the unemployment rate, IP, employment, CPI and the EBP; the bands represent 84% and 95% boostrapped confidence intervals. The estimation sample is January 1990-December 2017.

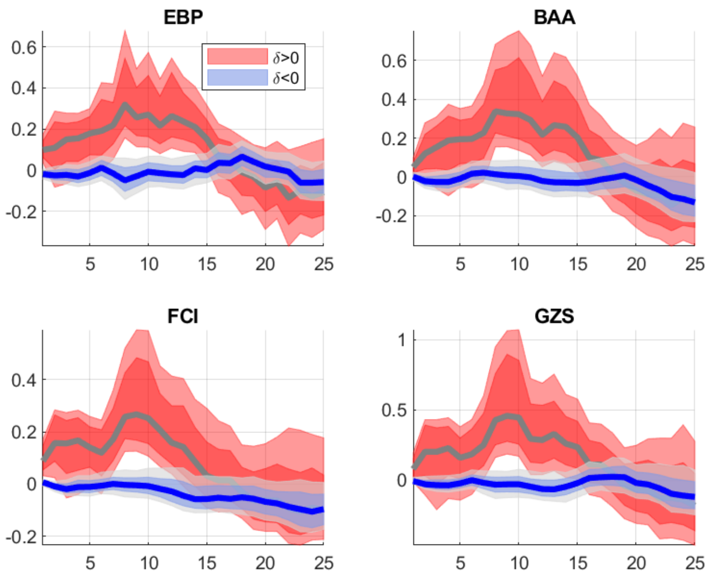

Figure 2: Asymmetric impact of monetary surprises on Asset Prices.
Response of asset prices to expansionary (blue) and contractionary (red) monetary policy shocks. The shock series comes from Jarociński and Karadi (2020). See also notes to Figure 1.

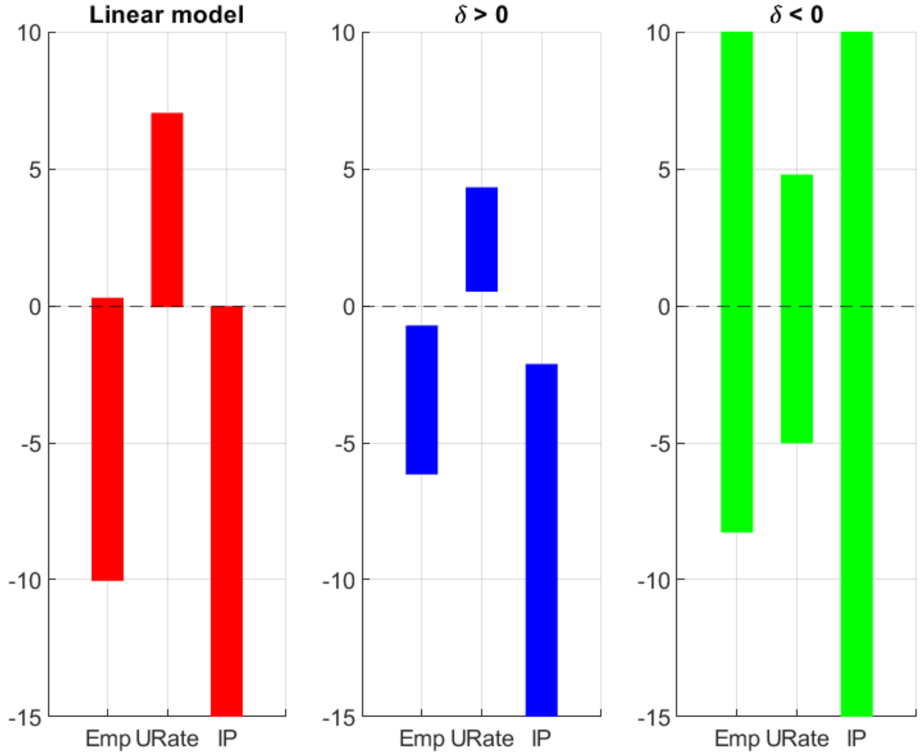

Figure 3: The asymmetric 'Financial Condition Multiplier' of Monetary Policy. The FCM is defined as the ratio between the responses of economic activity and the Excess Bond Premium (EBP) to a monetary policy shock at the 12-month horizon. The shocks come from Jarociński and Karadi (2020); economic activity is proxied alternatively by unemployment rate, industrial production and employment. The left panel shows FCMs obtained from a linear model conditioning on a 5 basis points increase in interest rates. The following panels show FCMs obtained from a nonlinear model, distinguishing between monetary contractions (center) and monetary expansions (right). The box edges represent the 5th and 95th percentiles of the bootstrapped distribution of the FCMs. The estimation sample is January 1990-December 2017.

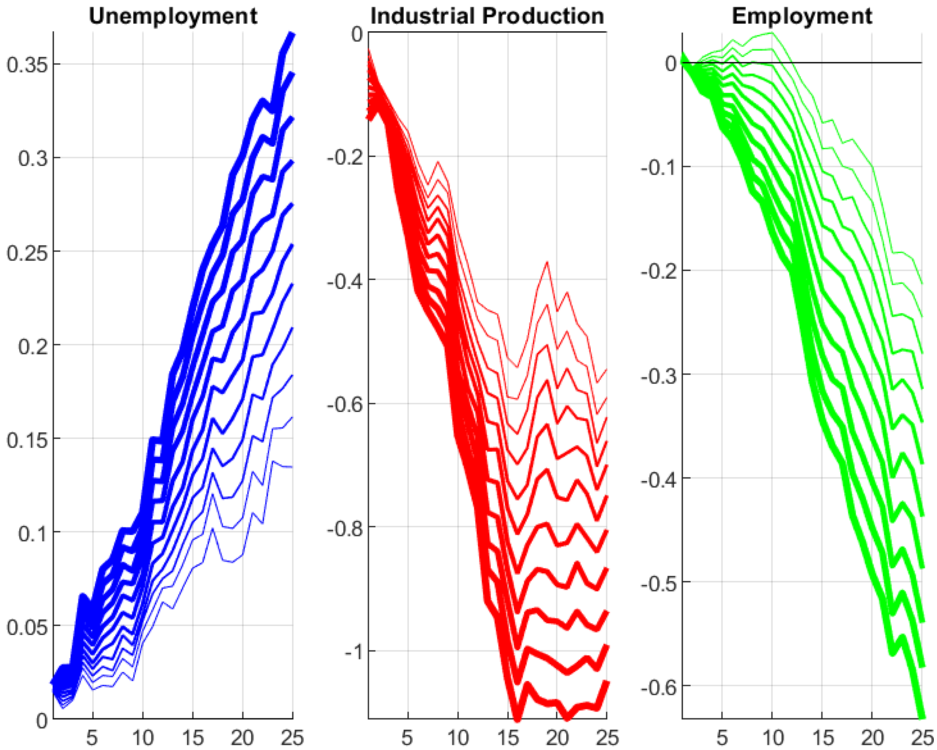

Figure 4: INFLUENCE OF CREDIT MARKETS IN A SYMMETRIC TRANSMISSION MECHANISM
The figure shows how the impact of a monetary tightening on unemployment rate, industrial production and employment varies depending on the financial market response to the shock. The shock is a one-standard-deviation increase in interest rates from Jarociński and Karadi (2020). The responses are obtained from a Kitagawa decomposition conditioning on alternative paths of the Excess Bond Premium.

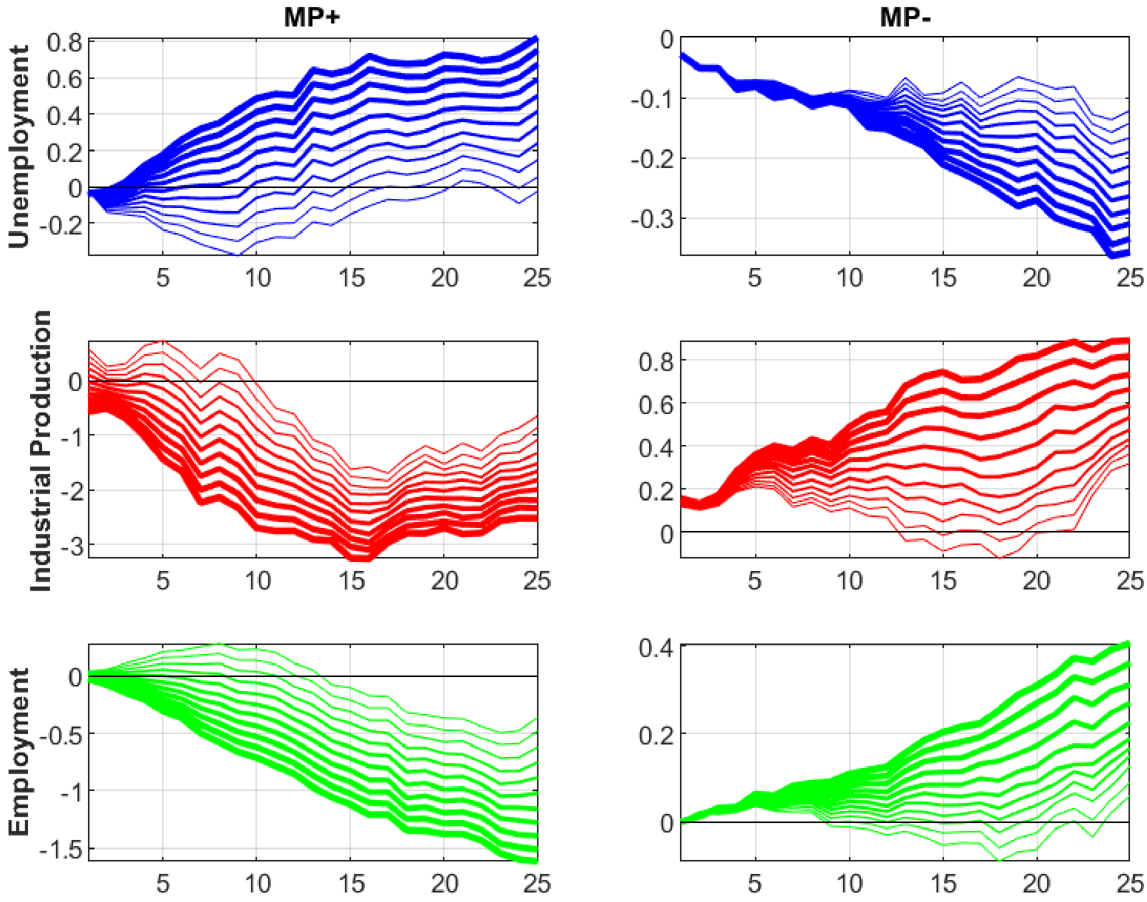

Figure 5: Influence of credit markets in an asymmetric transmission mechanism
The figure shows how the impact of a monetary shock on economic activity varies depending on the sign of the shock and the financial market response to it. Row 1 and 2 report respectively the responses to a one-standard-deviation increase and decrease in interest rates. For each shock and economic activity indicator, the responses are obtained conditioning on different EBP responses in the Kitagawa decomposition (see notes to Figure 4).

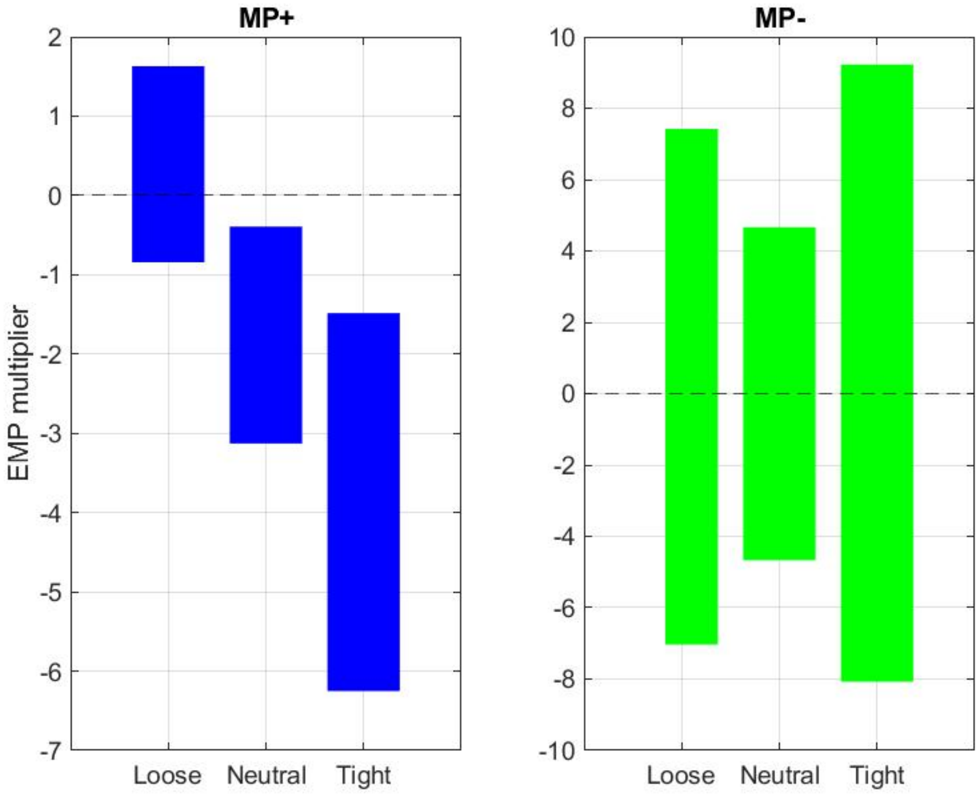

Figure 6: FINANCIAL CONDITION MULTIPLIERS (FCMS) ACROSS SHOCKS AND STATES
The FCM is the ratio between the Employment response and the Excess Bond Premium response at the 12-month horizon after a monetary policy surprise (see note to Figure 3). The figure shows the FCMs associated to a one-standard-deviation monetary tightening (left panel) and an equally-sized monetary loosening (right panel), conditioning on three alternative financial market states (horizontal axis). *Lose*, *neutral* and *tight* correspond to EBP being one standard deviation below the mean, at the mean or one standard deviation above the mean. The box edges are the 16th and 84th percentiles of the bootstrapped distribution of the multipliers.

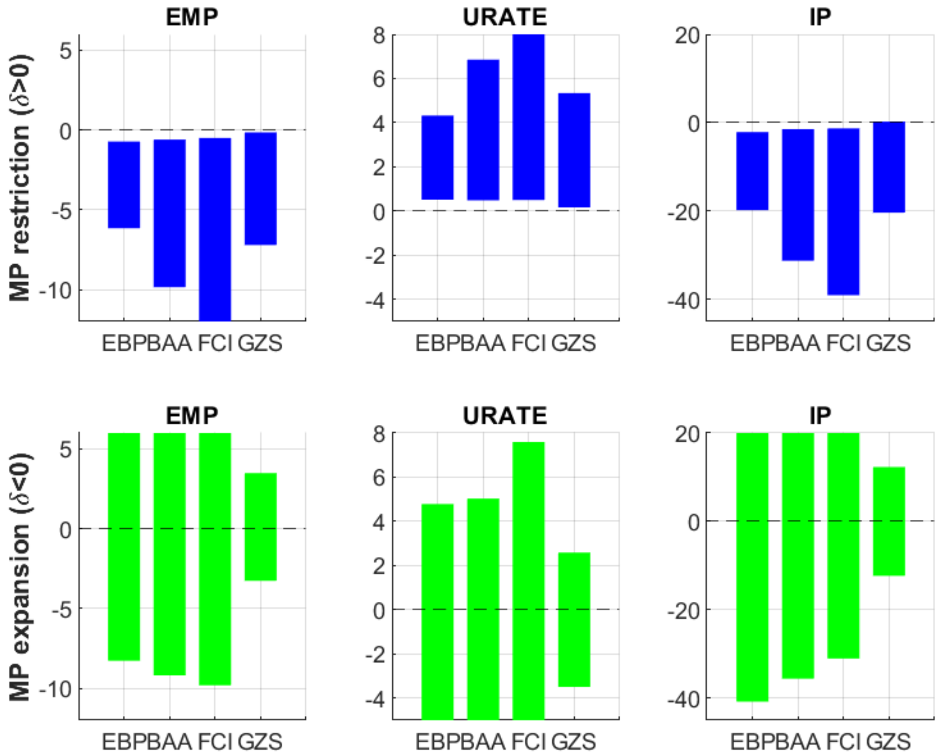

Figure 7: FCMs based on alternative financial indicators
The figure shows a range of financial condition multipliers (FCMs) for monetary policy shocks. A FCM is a ratio between the cumulative response of an economic activity and a financial indicator to a monetary shock at the 12-month horizon (see notes to Figure 6). The top row reports the FCMs attached to a monetary restriction, considering combinations of three activity indicators (unemployment rate, IP, employment) and four financial indicators (EBP, BAA spread, FCI, GZ spread). The bottom row shows the same FCMs conditioning on a monetary expansion. The box edges are the 5th and 95th percentiles of the bootstrapped distribution of the multipliers.

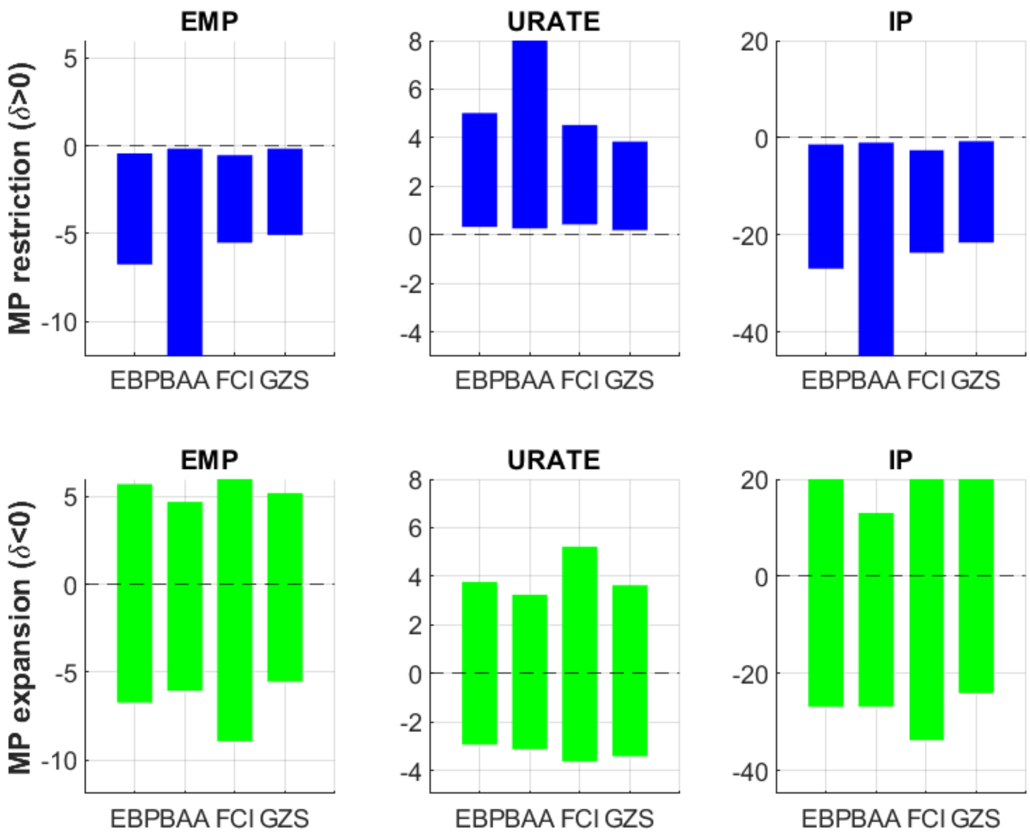

Figure 8: FCMs BASED ON AN ALTERNATIVE MONETARY POLICY SHOCK SERIES
The financial condition multiplier (FCM) is defined as the ratio between the cumulative responses of economic activity and financial conditions to a monetary shock at the 12-month horizon. The figure displays FCMs for a 5 basis points monetary restriction (top row) and a 5 basis points expansion (bottom row) using the monetary policy shocks of Miranda-Agrippino and Ricco (2021). See also note to Figure 7. The box edges represent the 5th and 95th percentiles of the bootstrapped distribution of the FCMs. The estimation sample is 1991-2015.

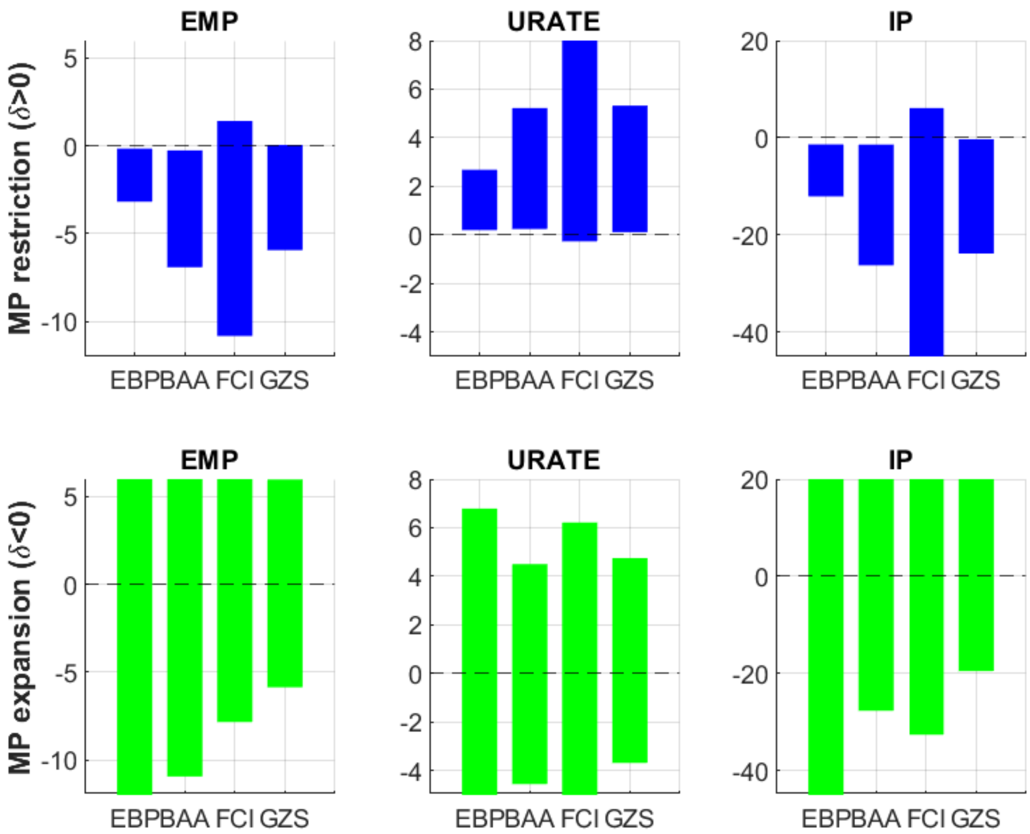

Figure 9: FCMs in periods of positive industrial production growth
The financial condition multiplier (FCM) is defined as the ratio between the cumulative responses of economic activity and financial conditions to a monetary shock at the 12-month horizon. Top and bottom row display respectively FCMs for a 5 basis points increase and decrease in interest rates, using alternative proxies of economic activity and financial conditions. The box edges represent the 5th and 95th percentiles of the bootstrapped distribution of the FCMs. See also note to Figure 7.

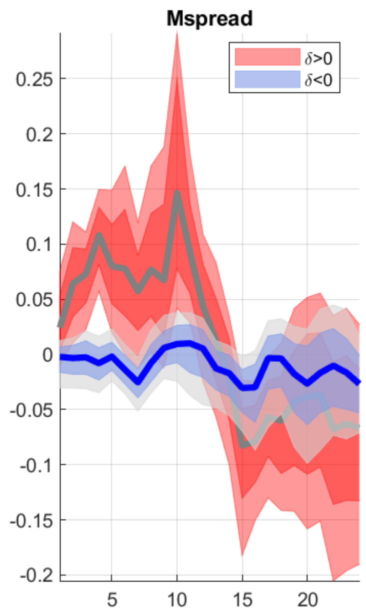

Figure 10: Asymmetric impact of monetary surprises on Household Credit
Response of the 30-year mortgage spread (*Mspread*) and the aggregate mortgage-to-GDP ratio (*HHMtoGDP*) to expansionary (blue) and contractionary (red) monetary policy shocks. See also notes to Figure 1.

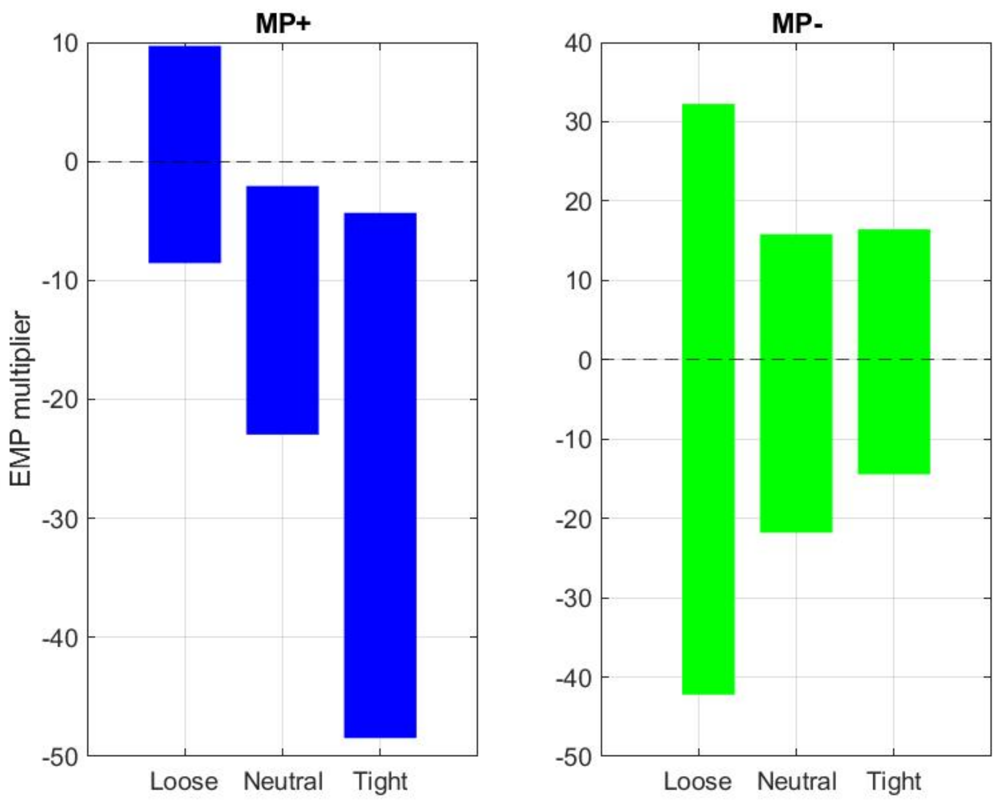

Figure 11: FCMs based on the 30-year Mortgage Spread
Ratios between cumulative employment responses and 30-year mortgage spread responses to restrictionary and expansionary monetary policy surprise (see note to Figure 6).

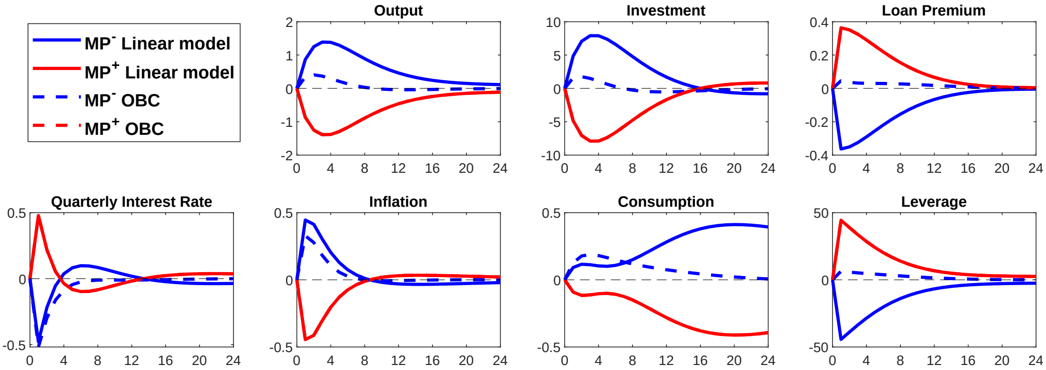

Figure 12: Monetary asymmetries in an economy with leveraged investors
Impact of expansionary (blue line) and contractionary (red line) monetary policy shocks in the Gertler and Karadi (2011) model. The shocks consist of a 50 basis points decrease or increase in interest rates (bottom left panel). Continuous lines show the responses from a linear solution where leverage constraints are assumed to bind at all times. Dashed lines show the responses with occasionally binding leverage constraints.

Decomposing the monetary policy multiplier

Annex – May 2022

Piergiorgio Alessandri Oscar Jordà Fabrizio Venditti

A Figures

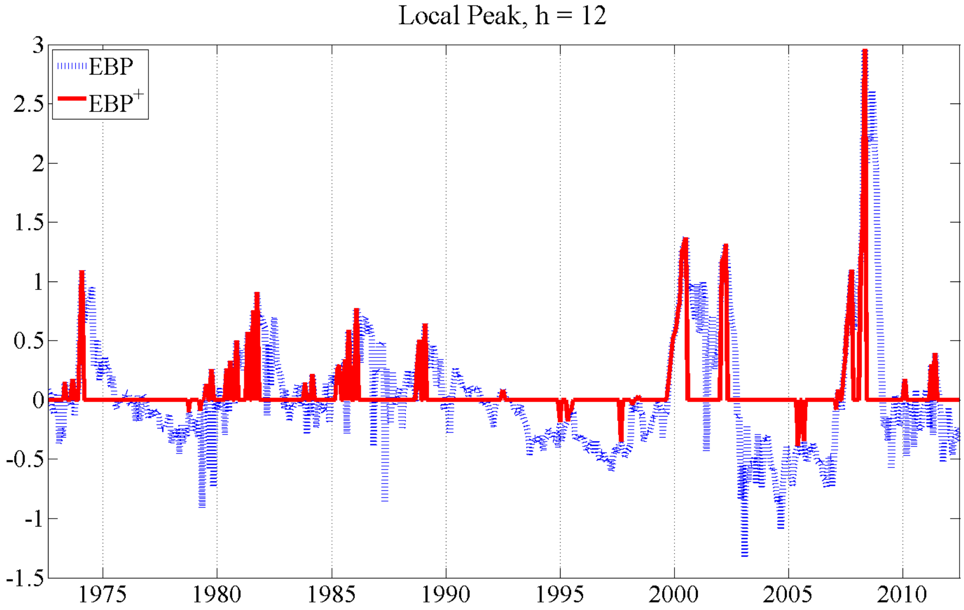

Figure A.1: Local Peaks of the Excess Bond Premium. The plot compares the Excess Bond Premium (Gilchrist and Zakrajsek, 2021) to the 'local peak' transformation of the Excess Bond Premium used in the predictive regressions of Section 2. This is computed as $\mathsf{EBP}_t^+(j)=\mathsf{EBP}_t\ \mathcal{I}\{\mathsf{EBP}_t>\max(\mathsf{EBP}_{t-1,t-2,\ldots,t-j})\}$ for h=12.

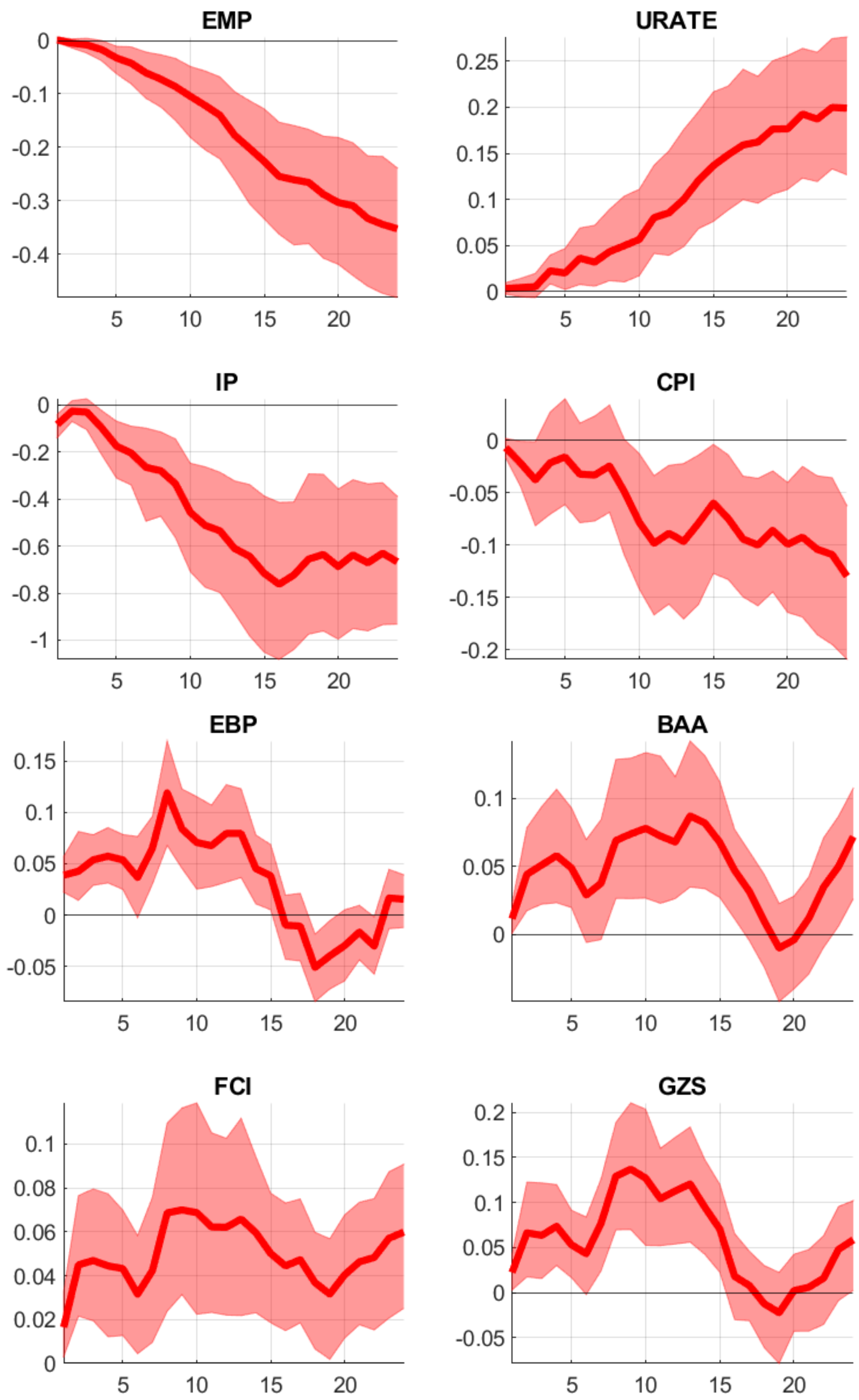

Figure A.2: IMPACT OF MONETARY POLICY SHOCKS IN THE LINEAR MODEL. The figure shows the impact of the monetary policy shocks identified by Jarocinsky and Karadi (2016) obtained from linear local projections. From the top-left corner, the responses refer to employment, unemployment rate, industrial production, consumer price index; Excess Bond Premium, BAA bond spread, Financial Condition Index, Gilchrist-Zakrajsek bond spread. The sample is January 1990-March 2019.

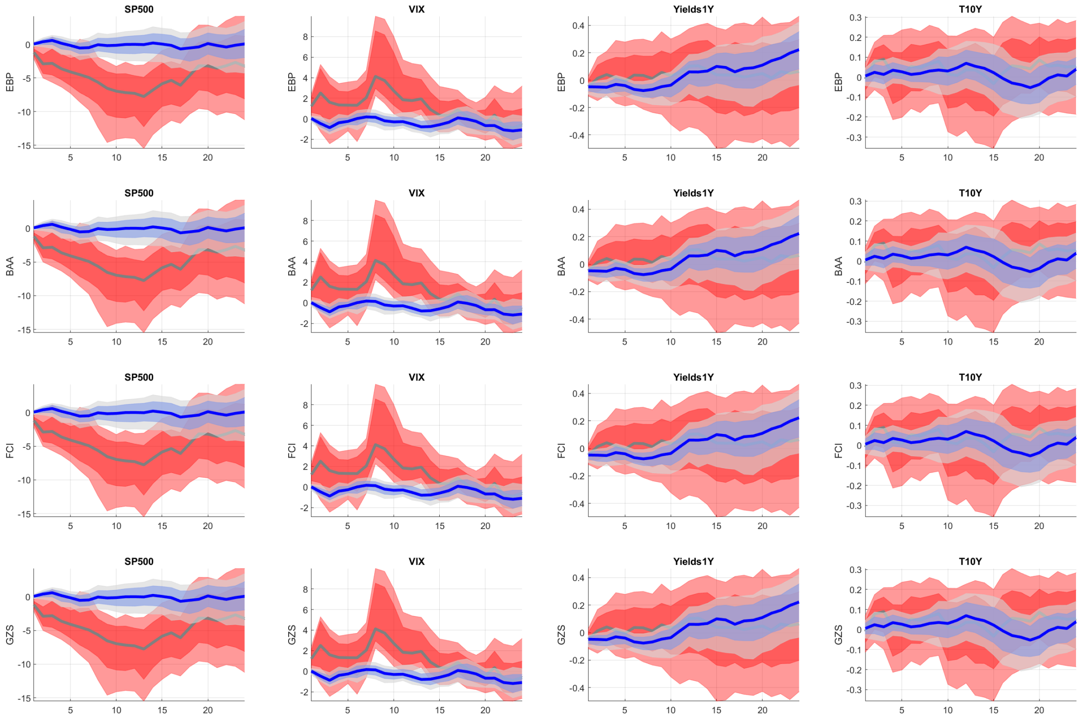

Figure A.3: Asymmetric Impact of monetary policy on stock and bond markets. Impact of the monetary policy shocks of Jarocinsky and Karadi (2016) in local projection models that discriminate between monetary expansions (blue) and contractions (red). The columns show the responses for, respectively, S&P500 stock price index, VIX index, 1-year and 10-year Treasury bill yields. The regressions include our baseline set of controls plus, alternatively, EBP (top row), BAA spread, FCI or the overall Gilchrist-Zakrajsek spread (bottom row). All responses are computed for a $\pm 1\sigma$ shock. The sample is January 1990-March 2019.

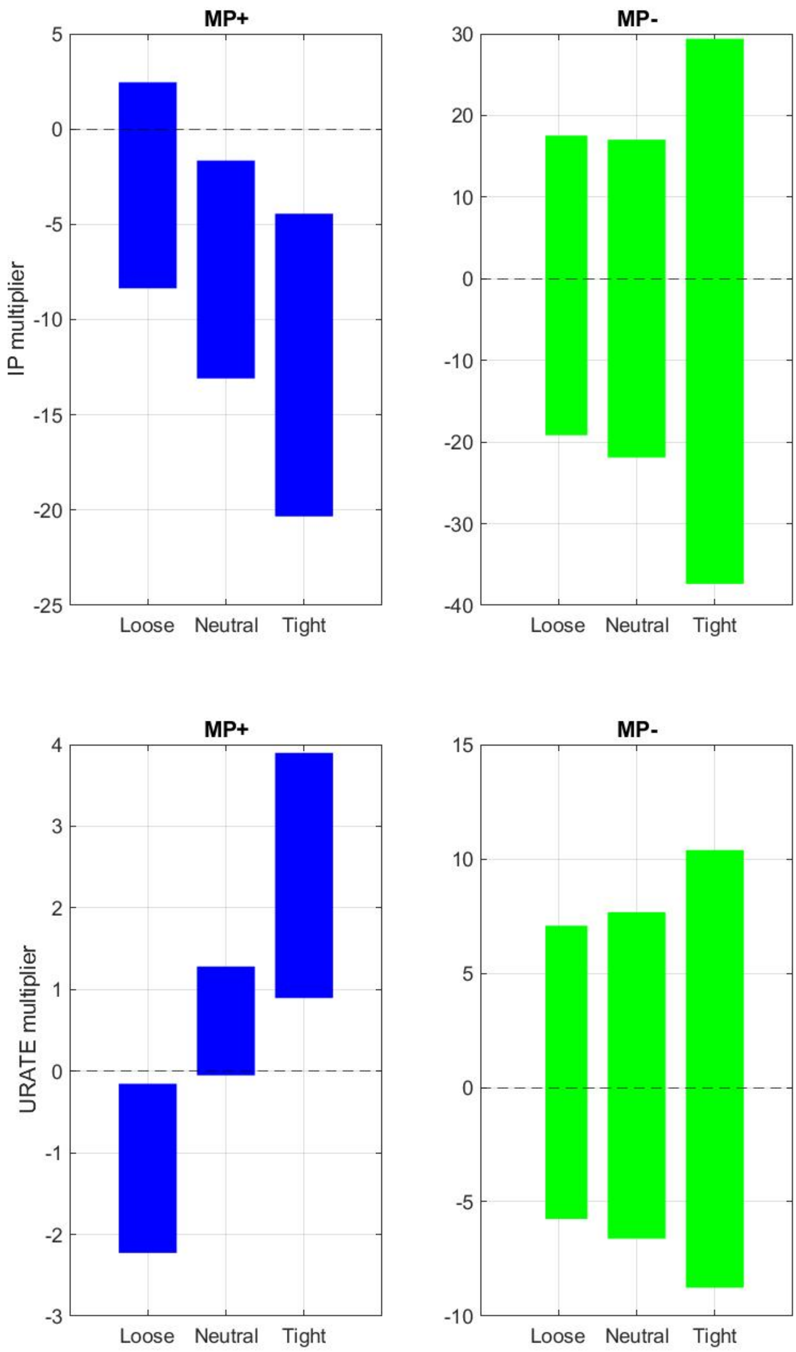

Figure A.4: FCMs for Unemployment and Industrial Production
The FCM is the ratio of 12-month-ahead responses of economic activity and bond spreads to an exogenous monetary policy shock. In the top row the FCMS are calculated using Industrial Production and EBP, distinguishing between (i) a 1σ monetary tightening (left panel) and a 1σ monetary expansion (right panel), and (ii) three alternative financial market states (horizontal axis). In the bottom row the calculations are replicated using Industrial Production and EBP. See notes to Figure 3 and Figure 6.

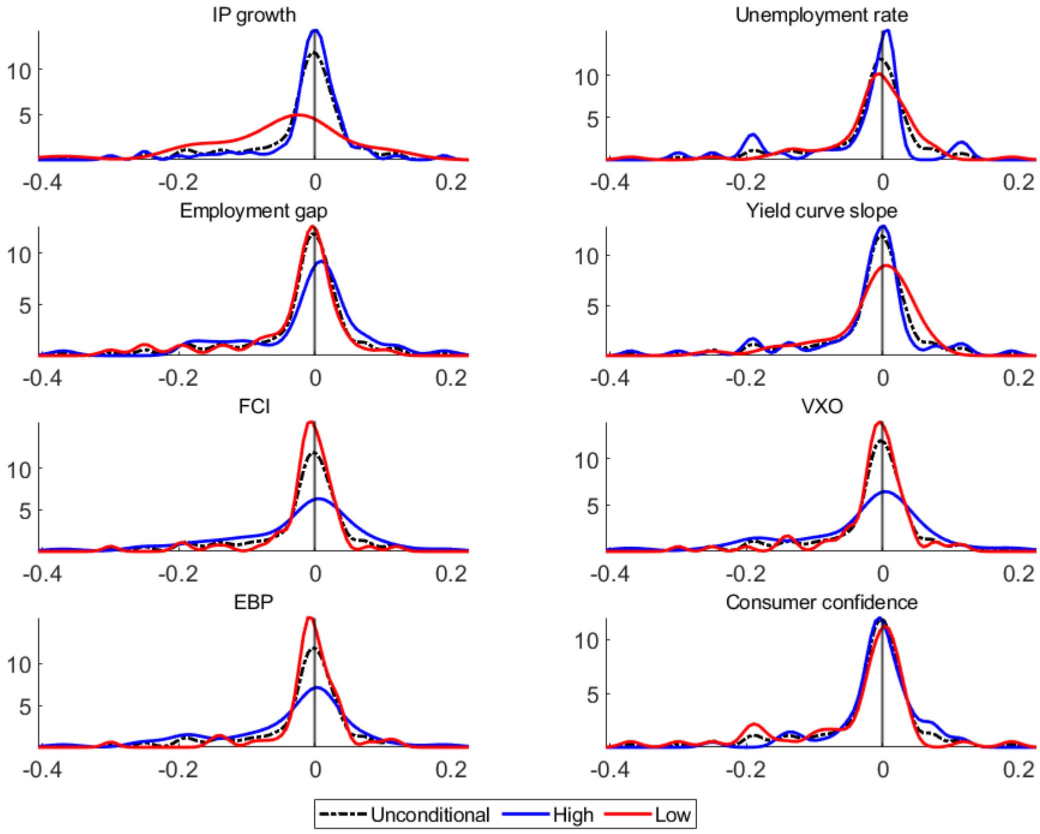

Figure A.5: Monetary policy shocks across business cycle phases
Distribution of the monetary policy shocks estimated by Jarociński and Karadi (2020) across macroeconomic states. The top-left corner shows the shock distributions obtained conditioning on positive (blue) or negative (red) annual growth in industrial production. The remaining plots show the distributions for above- (blue) or below-median (red) values of unemployment rate, employment gap, slope of the yield curve (i.e. difference between 10- and 1-year T-Bill yields), FCI, VXO, EBP and the Michigan Consumer Sentiment index. The unconditional distribution of the shocks is shown for comparison (black dashed line).

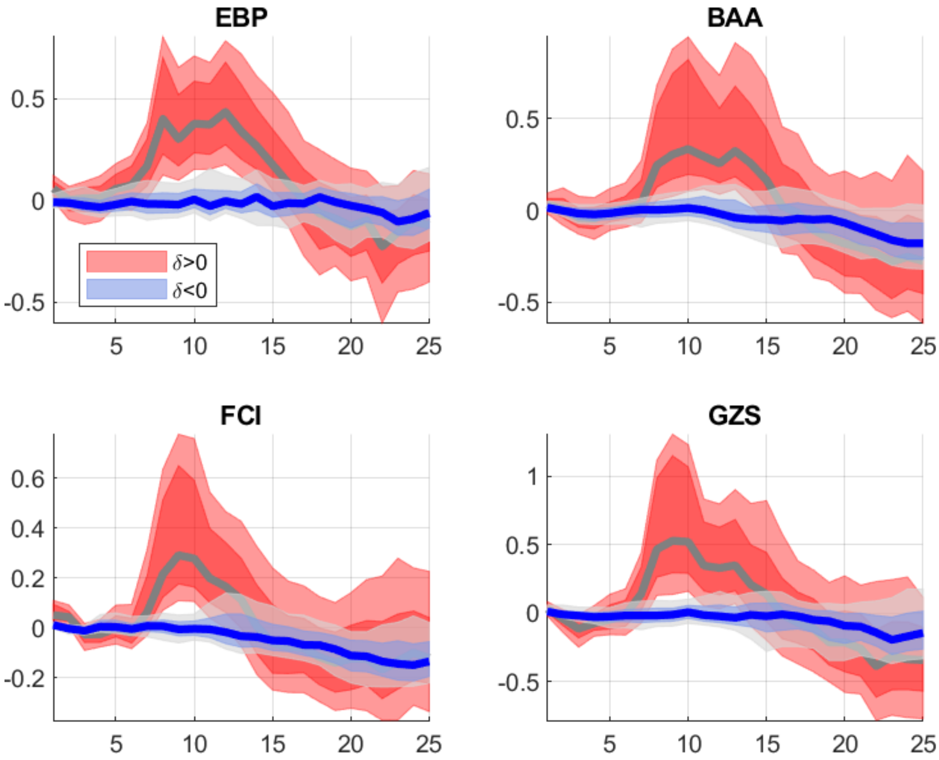

Figure A.6: Sign asymmetry in periods of positive growth – Financial Indicators
See notes to Figure 1. The estimation only exploits periods of positive annual IP growth.

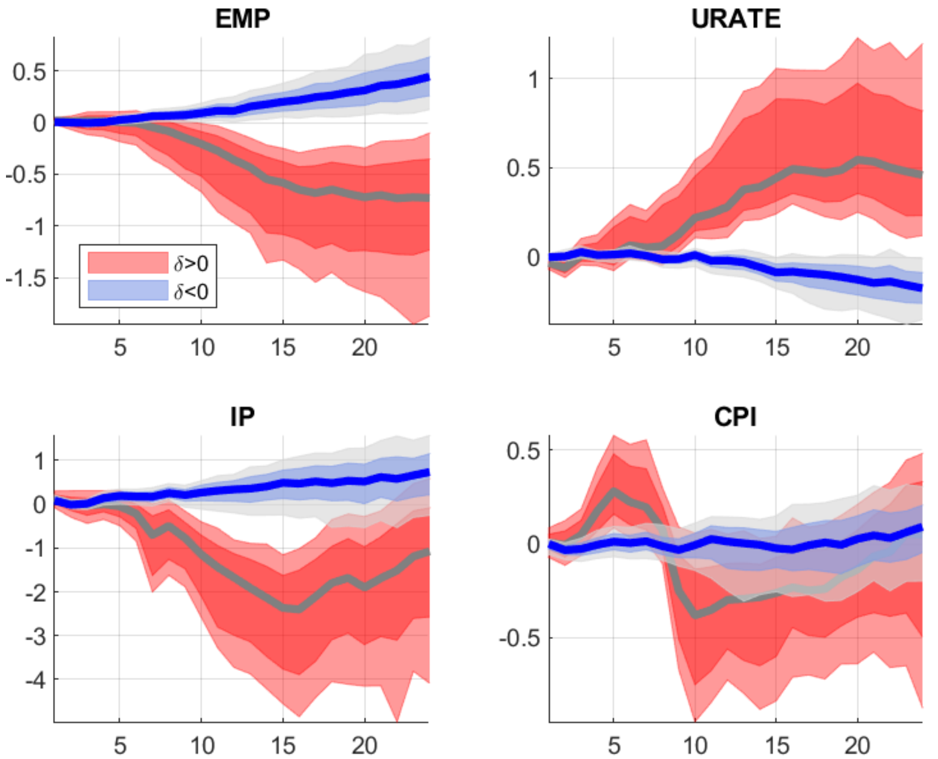

Figure A.7: Sign asymmetry in periods of positive growth – Economic activity
See notes to Figure 1. The estimation only exploits periods of positive annual IP growth.