

Asymmetric markup responses to monetary shocks over the business cycle

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ORIGINAL ARTICLE

Asymmetric markup responses to monetary shocks over the business cycle

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Abstract

A rich literature has long studied the asymmetric effects of monetary policy over the business cycle, generally presenting mixed results. Most of the empirical work, however, focuses on the responses of output and prices. Our analysis centres on the dynamics of the markup, given the key role that it plays in the transmission of monetary policy, the fact that it constitutes a key leading indicator for predicting economic and financial crises, its direct relationship with income distribution, and the scarce studies on the subject. Recent empirical findings suggest that the markup decreases (increases) in response to a monetary policy tightening (easing) shock, a counterintuitive result if we consider the basic New Keynesian model, which delivers a countercyclical response of the markup conditional on a monetary shock. We show that the dynamics of the markup depend on whether the monetary policy shock takes place during a period of expansion or recession, with the markup responding as expected in the New Keynesian model in recessions, but failing to do so in expansions. Our results have important policy implications, providing evidence that the transmission mechanism of monetary policy through the markup would not be operative during booms.

KEYWORDS

asymmetric responses, business cycle, local projections, markup, monetary shocks

JEL CLASSIFICATION

E24; E31; E32.

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1 | INTRODUCTION

One of the key transmission mechanisms of monetary policy (MP) within the New Keynesian (NK) framework rests on the countercyclical behaviour expected of the markup, conditional on an MP shock. As pointed out by Nekarda and Ramey (2020), the dependence of NK models on a countercyclical markup of price over the marginal cost was embraced by the literature in the early 1980s. Prior to this, Keynesian models relied on sticky wages for the transmission of shocks.

In the basic NK framework, the mechanism of transmission of monetary shocks through the markup is straightforward and appealing. Given that the price markup is defined as the inverse of the labour share, and since prices are sticky, when a contractionary (expansionary) monetary shock reduces (increases) aggregate demand, the price rigidity triggers an increase (decrease) in the markup. This increase (decrease) is equivalent to a decrease (increase) in unit labour costs that pushes down (up) inflation. As affirmed by Broer *et al.* (2020), the change in the markup influences output because it is associated with an increase in profits, which also respond countercyclically. Indeed, since in the NK textbook model workers also receive profit income, higher profits generate a positive wealth effect that induces a reduction in labour supply by households, reducing employment and output.

There is a vast literature studying the cyclical behaviour of the markup, and its relationship with economic and financial crises. For instance, the markup appears to be a leading indicator that falls before recessions start and increases before recoveries, and many applications have been devoted to the understanding of the relationship between markups and financial constraints (see, for example, Meinen and Soares 2022). Applications range from exploring the connection between markups, inflation and sticky prices in an NK framework (see, for example, Leith and Liu 2016), to examining the relationships among international trade, country size and markups (see, for example, Kiliç 2017), spanning a variety of fields in between. However, the evidence regarding the dynamics of the markup in the wake of a monetary shock is scarce and does not seem to have reached definitive results. In recent times, the markup is found to be procyclical in Nekarda and Ramey (2020) and in Cantore *et al.* (2021). These latter conclude that either the NK framework is not suitable to separate the dynamics of the markup and the labour share, or the markup is not countercyclical as expected in NK models.

We aim to provide further evidence regarding the conditional response of the markup to an MP shock. In particular, we deepen the analysis by studying whether the phase of the business cycle, in which the MP innovation takes place, influences the response. An important line of the literature has focused on when the asymmetric responses originate, due to the fact that shocks take place at different phases of the business cycle. However, most studies centre attention on the dynamics of output, to determine whether MP is more effective in booms than in recessions. Among these studies, that of Tenreyro and Thwaites (2016) is one of the most influential in recent years. Yet, to the best of our knowledge, we are the first to focus on the markup responses to MP shocks over the business cycle.

Using the MP shock estimated in Jarociński and Karadi (2020) as the external measure of the monetary innovation, we follow an identification strategy related to that of Tenreyro and Thwaites (2016) to assess the response of a set of state-of-the-art aggregated measures of the markup. The empirical strategy implements a local projections (LP) approach à la Jordà (2005), widely popularised in recent economic applications (see, for example, Jordà 2023), and a smooth local projections (SLP) approach in the line of Barnichon and Brownlees (2019), proven to increase the efficiency of the estimations. We estimate the markup responses for the period from 1990M2 to 2016M12, for which the MP shock is available, controlling as well for the existence of the Federal Reserve (Fed) information shock, also estimated in Jarociński and Karadi (2020). We obtain monthly data from quarterly interpolated data with the approach of Stock and Watson (2010), though we also show that our estimations are robust to the use of quarterly data.

Since the time span of estimation includes the Great Recession of 2008/9 and the zero lower bound period, we also conduct the analysis for a pre-crisis subsample as a robustness check.

Our main result is that the response of the markup to a contractionary (expansionary) MP shock differs depending on whether the economy is expanding or in recession. *A priori*, an MP tightening (easing) that takes place in recessions reduces (increases) output but increases (reduces) the markup (i.e. a countercyclical response). After an MP tightening (easing) in expansions, instead, both output and the markup display a negative (positive) response (i.e. a procyclical response), in agreement with the results of Nekarda and Ramey (2020) and Cantore *et al.* (2021)—with these latter papers performing the analysis without focusing on the phases of the business cycle. The findings remain robust across all estimations and specifications proposed, using a range of state-of-the-art markup measures. This holds true for different specifications (in levels and in long differences) and data frequencies (monthly and quarterly), various sets of control variables, proxy measures for the markup, and time spans (full sample and pre-crisis sample).

Interestingly, asymmetric markup responses arise because the same MP shock has different effects depending on whether the economy is in recession or expansion. During recessions, MP impacts output and the markup as expected in the baseline NK model. However, in expansions, the same policy fails to operate, leading to procyclical responses. This discrepancy could stem from various factors. First, different responses could arise from different price and/or wage stickiness. For example, if prices face higher rigidity in recessions or if prices are stickier than wages, then both tightening and easing shocks would trigger a countercyclical response. Second, as the markup reflects the firm's pricing power, a negative response of the markup after a tightening in expansions could occur due to firms prioritising market shares over margins, while financial constraints would lead them to prioritise these latter during downturns (see, for example, Gilchrist *et al.* 2017). Third, the asymmetries may be rooted in the dynamics of the labour market, with tightening shocks triggering a composition change of the workforce that pushes less productive workers out of the market in recessions (see, for example, Bils 1985; Solon *et al.* 1994; Elsby *et al.* 2010). This composition change would unwind after an easing shock. Finally, since in the baseline NK model the price markup can be derived from the NK Phillips curve (NKPC), the asymmetric responses could be grounded in a different effectiveness of MP to shape inflation expectations. In recessions, a decreasing markup after an easing would derive from inflation expectations increasing less than actual inflation, while in expansions, tightening shocks would cause inflation expectations to fall more than actual inflation. These results bring into our analysis a novel debate around the idea of 'sticky prices versus sticky expectations'.

The fact that MP shocks trigger a countercyclical response only in recessions suggests that the NK model cannot reconcile theory with the empirical evidence, at least not in expansions. Such findings are consistent with those of Cantore *et al.* (2021) and have important policy implications, since the role of NK models and their transmission mechanisms should be reconsidered in times of booms. Indeed, the asymmetric responses of the markup suggest that traditional interest rate tools may be less effective in expansions, and policymakers would need to consider alternatives, such as macroprudential policies and sector-specific interventions, or a flexible policy approach that is sensitive to the phase of the business cycle.

The rest of our paper is organised as follows. In Section 2, we provide coverage of the two strands of literature from which our work departs: (i) the cyclical dynamics of the markup, and (ii) testing the asymmetric responses of macroeconomics variables to MP shocks over the business cycle. We then describe our data in Section 3. Next, in Section 4, we detail the empirical strategy and LP modelling specification that we adopt to evaluate the responses of the markup to MP shocks over the business cycle. Thereafter, our main results are presented in Section 5, while we enumerate the extensive robustness checks performed in Section 6. Penultimately, in Section 7, we discuss our results from a theoretical perspective and provide a framework to understand them. Finally, in Section 8, we venture some theoretical and policy implications, and conclude the paper.

2 | LITERATURE REVIEW

We build on two strands of literature. On one hand, our paper resonates with the literature analysing the cyclicity of the markup. On the other hand, it builds on the literature testing for asymmetric responses of macroeconomic variables to MP shocks over the business cycle.

The first strand belongs to a large body of work debating the unconditional cyclicity of the markup—a debate that remains open. Unconditional cyclicity refers to the correlation between the markup and real GDP (RGDP), and a vast literature has studied the link between both variables. Many applications have worked with measures of the markup based on the inverse of the labour share, while others have constructed markups directly from data on revenues or variable costs, or from developing the concept of the Solow residual, among other strategies. In general, the literature has produced conflicting results. Countercyclicity is reported by Bils (1987), Rotemberg and Woodford (1991, 1999), Oliveira Martins *et al.* (2002), Galí *et al.* (2007), and Mazzoli and Lombardini (2021), among others. Acyclicity or procyclicality, instead, is found in Domowitz *et al.* (1986), Chirinko and Fazzari (1994), Morrison (1994), Gomme and Greenwood (1995), Haskel *et al.* (1995), Galeotti and Schianterelli (1998), Marchetti (2002), Rios-Rull and Santaaulàlia-Llopis (2010).

More recently, Bils *et al.* (2018) estimate countercyclical markups again by examining self-employment and intermediate inputs, since they argue that wages may be smoothed versions of the true cyclical price of labour. This countercyclicity would be compatible, for instance, with high price stickiness in recessions and/or firms choosing a higher markup in recessions, as found in Gilchrist *et al.* (2017).

Nekarda and Ramey (2020) provide a wide range of measures of the markup, finding that in general, estimates relying on Cobb–Douglas production functions are slightly procyclical or acyclical. Instead, those estimated through constant elasticity of substitution (CES) production functions, based on output–capital ratio and with capital utilization estimated from the workweek of capital, are moderately countercyclical.

Empirical applications analysing the conditional cyclicity of the markup to an MP shock are, instead, scarce. Nekarda and Ramey (2020) find a procyclical response of the markup conditional on an MP shock. Cantore *et al.* (2021) centre the analysis on the response of the labour share, and find that an MP tightening increases the labour share, concluding that either NK models are unable to separate the dynamics of the labour share from the markup, or the markup does not respond in the way that NK models predict. The approach of Cantore *et al.* (2021) is based on the use of a vector autoregressive (VAR) model, and estimates are presented for the USA, the euro area, the UK, Australia, and Canada until the year 2007.

The scope of our paper, working with a set of alternative measures of the markup, is similar to that of Nekarda and Ramey (2020) and Cantore *et al.* (2021), though we set forth a different empirical strategy. The use of LP provides a level of flexibility that is not present in a VAR model, since the LP approach does not constrain the shape of the impulse response functions (IRFs), and each response is estimated at each horizon instead of extrapolating them by iterating the autoregressive matrix. Moreover, we go a step further to test whether the responses of the markup depend on the phase of the business cycle that the economy is going through. Thus, we build on a second important strand of the literature, focused on the study of the asymmetric responses of macroeconomic variables to certain features of the monetary shocks that hit the economy. Specifically, this literature has analysed the asymmetric effects triggered by shocks that have taken place at different phases of the business cycle (recession or expansion), shocks of different sizes (large or small), and shocks with different direction (accommodative or contractionary) (see, for example, Cover 1992; Morgan 1993; Thoma 1994; Karras 1996; Weise 1999; Peersman and Smets 2001; Kaufmann 2002; Ravn and Sola 2004; Lo and Piger 2005; Tenreiro and Thwaites 2016; Angrist *et al.* 2018; Stockwell 2021).

Our research departs from Tenreyro and Thwaites (2016), where the key question addressed is whether MP is less effective under recessions. However, the main differences are (apart from the ones that we cover in Section 4 on the empirical strategy): (i) we focus on the response dynamics of the markup (rather than output) conditional on an MP shock; and (ii) instead of using the monetary shock of Romer and Romer (2004) as the exogenous measure of the MP shock, we adopt the measure of Jarociński and Karadi (2020) to control for information shocks and overcome the zero lower bound constraint, permitting the analysis to be extended beyond 2007 to include the post Great Recession era.

Applications seeking to understand the asymmetric dynamics of the markup conditional on an MP shock that takes place at different phases of the business cycle are, to the best of our knowledge, non-existent. Consequently, the empirical contribution that we make is crucial, since we aim to provide evidence to understand how the transmission mechanisms of MP may vary across the phases of the business cycle. In addition, the relationship between the markup and key economic variables, such as profits and the labour share, as well as its connection to financial and economic crises, leaves space to potentially open several leads of research aimed at understanding how these mechanisms may relate to other macroeconomic variables and phenomena.

3 | THE DATA

We first focus on the dependent variables, with special attention given to the differences between the alternative measures of the markup that we use in this paper. We then turn to the analysis of the MP shock of Jarociński and Karadi (2020).

3.1 | The dependent variables

We use four time series for the US economy to evaluate the effects of monetary shocks. First, we use RGDP as a reference for assessing the results obtained from the markup dynamics. Second, we use a baseline measure of the markup estimated as the inverse of the labour share in the private business sector— M_CD . Nekarda and Ramey (2020) explain that this measure of the markup is consistent with those measured in the NK framework, and it is derived from the assumption of Cobb–Douglas technology and the absence of overhead labour. Third, we use an estimate of the markup derived from a CES production function, measured by the output–capital ratio with variable utilization of capital based on the workweek of capital— M_CES_VUK . Fourth, we use a measure similar to M_CES_VUK that allows for overhead labour— $M_CES_VUK_OH$.

The macroeconomic series that we use cover the period 1990Q1–2016Q4 and come from three different sources. The series for RGDP is retrieved from the database of the Federal Reserve Bank of St Louis.¹ The labour share in the private business sector comes from the Bureau of Labor Statistics (BLS) and is calculated as total labour compensation divided by value-added.² Finally, the two measures of the markup based on CES production functions are the preferred measures calculated by Nekarda and Ramey (2020).³

To control for the independent effect of the season on macroeconomic variables, following Olivei and Tenreyro (2010), we base the analysis on seasonally adjusted data. Indeed, given the fact that MP shocks are distributed throughout the year, it is important to control for the different effects that the timing of the shocks may carry.

Since the aim of the paper is to estimate the IRFs for these variables to the MP shock of Jarociński and Karadi (2020), using data for the period 1990M2–2016M12 for which the shock is available, the immediate implication of this objective is that limited observations are available at quarterly frequency. Consequently, resorting to the methodology implemented by Jarociński and Karadi (2020), which is founded on the work of Bernanke *et al.* (1997) and

TABLE 1 Correlation coefficients between the markup and real GDP growth.

	M_CD	M_CES_VUK	M_CES_VUK_OH
RGDP growth (quarterly)	0.20	0.01	-0.07
RGDP growth (monthly)	0.23	-0.07	-0.02

Notes: The table presents the correlation coefficients for the quarterly and interpolated (monthly) data for the period 1990–2016. All series are in rates of variation and annualised. M_CD stands for the baseline measure of the markup, calculated as the inverse of the labour share in the private business sector derived from the standard assumptions of Cobb–Douglas technology and the absence of overhead labour. M_CES_VUK stands for the estimate of the markup assuming a CES production function, measured by the output–capital ratio and variable utilization of capital based on the workweek of capital. M_CES_VUK_OH constitutes a measure of the markup similar to M_CES_VUK, but it also allows for overhead labour. Source: authors' calculations based on data retrieved from the BLS, the Federal Reserve Bank of St Louis, and Nekarda and Ramey (2020).

Stock and Watson (2010), we transform the data from quarterly into monthly frequency through a direct approach that employs the Kalman filter. In essence, using series available at monthly frequency, we interpolate quarterly series for each month of the quarter. As presented in Online Appendix A, the series of industrial production and unemployment serve as input for the transformation of the series of RGDP and, in turn, the interpolated RGDP serves as input to interpolate the markup measures.⁴ Table 1 shows the correlation coefficients between RGDP and the markup measures, in rates of variation, at both quarterly and monthly frequency. It may be observed that the latter keep the correlation properties of the original series, experiencing only minor changes in the coefficients.

Interestingly, for the period under analysis and an unconditional approach, the baseline measure of the markup based on Cobb–Douglas technology (M_CD) appears to be mildly procyclical, just as in Nekarda and Ramey (2020), while the estimates based on CES production functions are acyclical, with the coefficients moving around zero.

The dynamics of the baseline measure of the markup and RGDP growth are presented in Figure 1. A simple inspection of the series shows that after falling during the recession of the beginning of the 1990s, the markup increases until around 1997. Then it decreases and reaches its minimum around 2001, continuously growing thereafter until 2006. It drops just before the start of the Great Recession, and starts an increasing path in the middle of the crisis, stabilising at over 0.55 after 2012. As accounted in Mazzoli and Lombardini (2021), the markup seems to behave as a leading indicator of the economy, reverting its trend before RGDP does, falling before recessions start, and increasing in the middle of the contractions, just before the recovery. According to Nekarda and Ramey (2020), the markup seems to peak around the middle of expansions, to decline going into recessions, and finally to rise when coming out of a recession. This suggests that overcoming a recessionary phase carries a reduction in the labour share, and the intensity of the reduction seems to be associated with the intensity of the recession and the recovery. This is a key consideration in the case of the US economy, with business cycles that, on average, are known to experience strong recoveries (see, for example, Kohlscheen *et al.* 2024).

Figure 2 presents the two alternative measures of the markup, along with the baseline estimate. As shown in Nekarda and Ramey (2020), our baseline measure of the markup, given by the inverse of the labour share, can be linked to our measures based on CES production functions according to the expression

$$M_{CES} = M_{CD} + \ln \left[1 - \alpha_k \left(\frac{Y_t}{u_t K_t} \right)^{(1/\sigma)-1} \right], \quad (1)$$

where M_{CD} and M_{CES} are the log measures of our baseline markup and the markup based on CES technology, respectively, σ is the elasticity of substitution between labour and

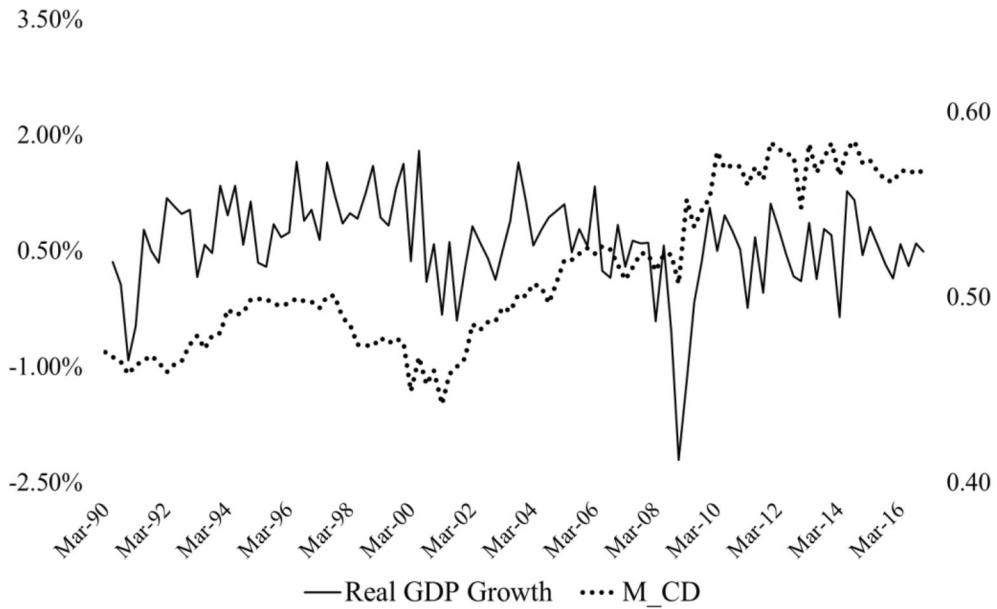


FIGURE 1 Evolution of real GDP growth (left-hand axis) and the markup in log (right-hand axis). *Notes:* M_CD stands for the baseline measure of the markup, calculated as the inverse of the labour share in the private business sector and derived from the standard assumptions of a Cobb–Douglas production function and the absence of overhead labour. Source: authors’ calculations based on data retrieved from the BLS and the Federal Reserve Bank of St Louis.

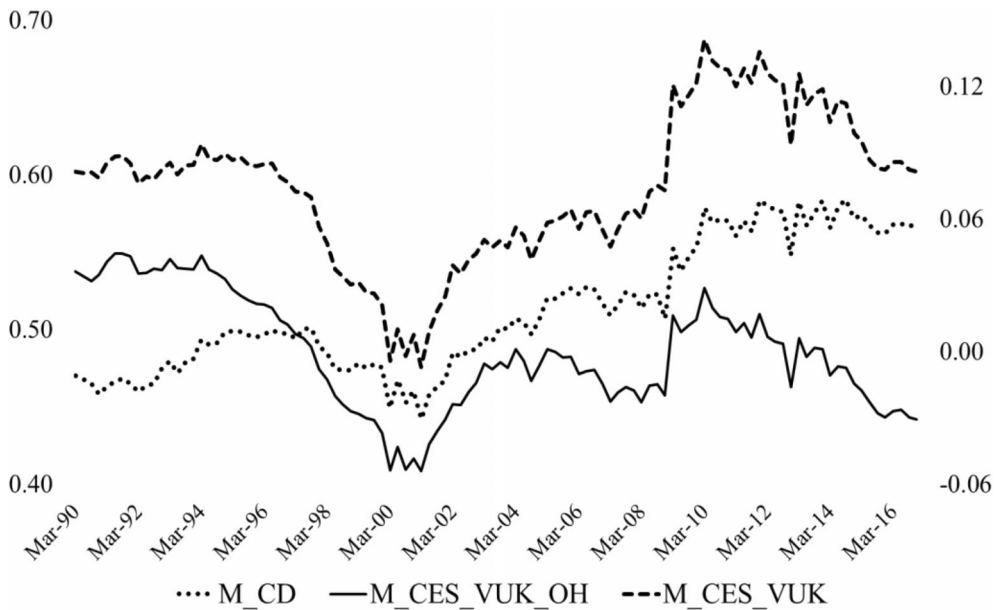


FIGURE 2 Estimates of the markup in log. *Notes:* M_CD (left-hand axis) stands for the baseline measure of the markup, calculated as the inverse of the labour share in the private business sector derived from the standard assumptions of Cobb–Douglas technology and the absence of overhead labour. M_CES_VUK (right-hand axis) stands for the estimate of the markup assuming a CES production function, measured by the output–capital ratio and variable utilization of capital based on the workweek of capital. M_CES_VUK_OH (left-hand axis) constitutes a measure of the markup similar to M_CES_VUK, but it also allows for overhead labour. Source: authors’ calculations based on data retrieved from the BLS and Nekarda and Ramey (2020).

capital, α_k is a distribution parameter, and in parentheses we have the ratio of output to utilised capital.

Since there are no available series of capital utilization (u_t), Nekarda and Ramey (2020) make different assumptions about the output-to-utilised-capital ratio, among which they rule in favour of assuming variable utilization of capital, and estimate utilization series from data on the work-week of capital. Their preference lies in the fact that markups based on variable utilization of capital show the lowest cyclical bias of all measures of the markup calculated. With regard to σ , they assume the elasticity of substitution to be 0.5, based on the work of Chirinko (2008).

An important difference that we detect in Figure 2 with the measures based on CES technology is given by the earlier decreasing path that starts around 1994, whereas the baseline measure starts declining only in 1998. Considering equation (1), the right-hand side has two terms, M_{CD} (the baseline markup, which can be adjusted or not for overhead labour), and the term that depends on the ratio of output to utilised capital, which is the same for both measures using CES production functions. While the difference in levels between these two latter measures is given by the adjustment of M_{CD} for overhead labour, the negative trend that they share starting in the mid-1990s is given by the increase in the ratio of output to utilised capital. After 2000, the trend in the increase of the measure adjusted for overhead labour becomes much milder. This is due primarily to the slower growth of the first term, which, when adjusted for overhead labour, increased by less than 8% during the period 2000–2016. In contrast, when unadjusted, it increased by around 30% over the same period.

In addition, the measures based on CES production functions start falling after 2010, when the baseline measure remains quite stable. This, again, is explained by the increase in the ratio of output to utilised capital, which offsets the increase in the first term (both adjusted and unadjusted). These differences among different measures are important, since they suggest different dynamics for the evolution of the labour share, the markup and, most probably, profits. However, we should note that even when differences are perceived in the trends of each measure, they share a similar behaviour when performing the analysis from a business-cycle perspective. Indeed, the markup seems to behave as a leading indicator for crises and recoveries, and given its close connection with profits, it provides some hints on the evolution of these during the phases of the business cycle.

3.2 | The monetary shock of Jarociński and Karadi (2020)

The work of Jarociński and Karadi (2020) attempts to deconstruct MP surprises and the role played by information shocks in the USA and the euro area. A key contribution of their paper is to disentangle MP shocks from contemporaneous information shocks by analysing the high-frequency comovement of interest rates and stock prices in a narrow window around policy announcements. Through a Bayesian structural VAR (BVAR) approach, the responses of macroeconomic variables to both shocks are then evaluated. Figure 3 presents the monetary shock estimated in the paper, where it is possible to distinguish between shocks taking place in recessions and expansions.

As affirmed by Jarociński and Karadi (2020), shocks occur throughout the sample, without periods of particularly high concentration or differing magnitudes. Of course, it is imperative to point out the important magnitude of shocks taking place around the September 2001 terrorist attack on the USA and around the Great Recession of the late 2000s.

Importantly, Figure 3 illustrates an interesting fact revealed by the MP shock: both easing and tightening shocks have taken place during recessions and expansions. This is better understood from Table 2, which illustrates that at least 10 (15) tightening (easing) shocks took place during a recession between 1990 and 2016, averaging each of those shocks around five (nine) basis points (bps). The tightening shocks that take place in recessions present an order of magnitude that is

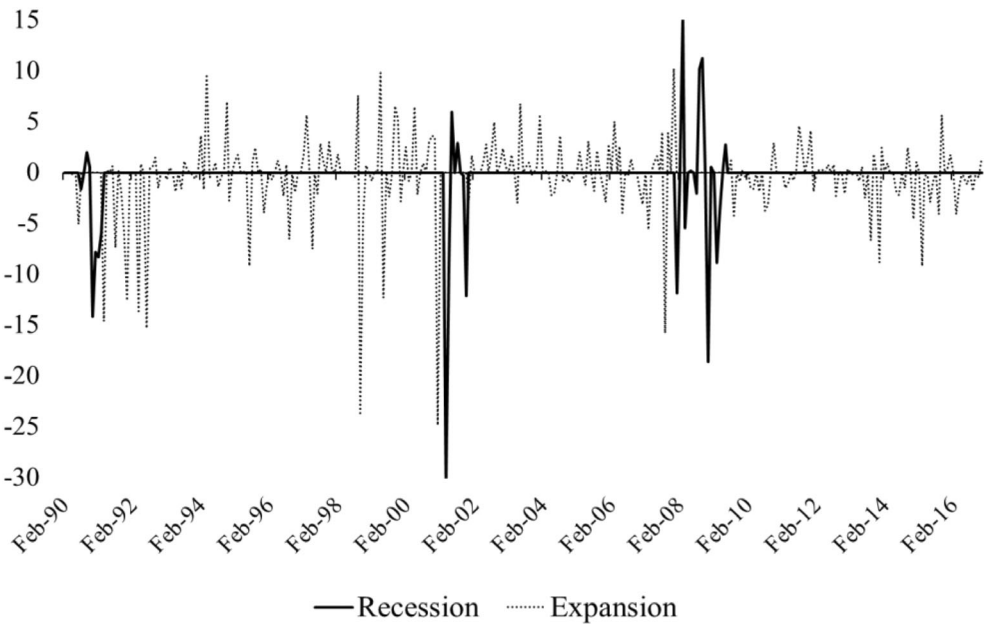


FIGURE 3 Monetary shock of Jarociński and Karadi (2020) (in basis points).

TABLE 2 Average monetary shock of Jarociński and Karadi (2020).

	Average tightening MP shock	Average easing MP shock
Recession	5.1	−9.4
Occurrences	10	15
Expansion	2.2	−3.3
Occurrences	96	101

Notes: The table presents the average monetary shock in recessions and expansions (in basis points).

more than twice the average of tightening shocks taking place in expansions. Something similar happens with easing shocks. In expansions, interestingly, both tightening and easing shocks present around one hundred occurrences, and with a higher magnitude of easing shocks, we observe a slightly negative average for MP shocks. This implies that, on average, MP shocks have been negative across the sample, though in expansions the average shock is almost null, well below one bp. This series is, in fact, the motivation behind the empirical exercise that we propose in this paper, since the possibility exists that even when the direction of the shocks is the same, always tightening or easing, they might still trigger different dynamics on the main relevant macroeconomic variables depending on the phase of the business cycle in which they occur.

4 | THE MODEL

The LP approach has become a widely used methodology to estimate IRFs, and is proven to have some advantages over structural VAR specifications (see Jordà 2005). For instance, LP provide a simpler and more flexible alternative to capture non-linear specifications in multivariate contexts

and are more robust to misspecifications. In addition, they constitute a perfect and intuitive tool to make inferences, estimating a simple ordinary least squares (OLS) regression at each horizon instead of relying on the extrapolation of IRFs at distant horizons by iterating the autoregressive matrix. As a result, the use of LP has spread across a wide range of applied macroeconomic applications (see, for example, Jordà 2023).

The basic LP approach implies estimating an equation of the type

$$y_{t+h} = c + \beta_h \epsilon_t^{mp} + \rho'_h x_t + \varepsilon_{t+h}, \quad h = 0, \dots, H, \quad (2)$$

where y_{t+h} is the dependent variable h periods ahead, c is a constant, ϵ_t^{mp} is the MP shock estimated by Jarociński and Karadi (2020), x_t is a vector of control variables, and ε_{t+h} are the residuals. The estimated coefficients β_h , for $h = 0, \dots, H$, represent the IRFs of the variable of interest at time $t + h$ to the MP shock at time t .

Since our idea is to test whether MP shocks display a different effect depending on the phase of the business cycle the economy is going through, the baseline specification becomes

$$y_{t+h} = REC_t \left(\beta_{h,R} \epsilon_t^{mp} + \rho'_{h,R} x_t \right) + (1 - REC_t) \left(\beta_{h,E} \epsilon_t^{mp} + \rho'_{h,E} x_t \right) + u_{t+h}, \quad (3)$$

where y_{t+h} is the dependent variable at time $t + h$, x_t is always the vector of control variables at time t , and $\beta_{h,R}$ ($\beta_{h,E}$) is the response of the dependent variable at time $t + h$ to MP innovations in recessions (expansions) that took place at time t . This specification is in line with that of Tenreiro and Thwaites (2016). However, instead of using output as dependent variable and resorting to a smooth transition approach, we estimate the responses for each dependent variable (output and our markup measures) using a threshold LP model—similar to Stockwell (2021) and, recently, Ahmed *et al.* (2024)—and decomposing the monetary shock over US business cycle phases. We decompose the monetary shock using the National Bureau of Economic Research (NBER) recession indicator to produce the variable REC_t ,⁵ which takes value 1 when the economy is in recession, and 0 otherwise.⁶

Looking at equation (3), we know that when the economy is in recession, we retain the term of the equation that interacts with REC_t , while in expansions, we retain the one interacting with $1 - REC_t$. To get the IRFs to both tightening and easing shocks, a decomposition of the MP shock is necessary. Indeed, we can focus on each of the phases of the business cycle, one at a time, and we can estimate the responses to tightening and easing shocks as in Funashima (2022), resorting to the specification

$$y_{t+h} = c + \beta_{h,R(E)}^+ \epsilon_{t,R(E)}^+ + \beta_{h,R(E)}^- \epsilon_{t,R(E)}^- + \rho'_{h,R(E)} x_t + v_{t+h,R(E)}, \quad (4)$$

where we have disentangled the IRFs to a tightening ($\beta_{h,R(E)}^+$) and easing ($\beta_{h,R(E)}^-$) shock that take place either in recessions or in expansions,⁷ and the shock in recessions (expansions) is equal to $\epsilon_{t,R} = \epsilon_{t,R}^+ + \epsilon_{t,R}^-$ ($\epsilon_{t,E} = \epsilon_{t,E}^+ + \epsilon_{t,E}^-$).

A further refinement to the LP methodology is the SLP approach put forward in Barnichon and Brownlees (2019). Their technique addresses the shortcoming that the non-parametric nature of LP comes at an efficiency cost, producing excessive variability in the estimator. This may be especially severe when working with relatively high frequency macroeconomic data, such as at monthly frequency (see, for example, Funashima 2022). Consequently, we perform the estimations using standard LP as in Jordà (2005), but we also estimate the SLP as robustness, preserving the flexibility of standard LP, and increasing precision based on a B-spline smoothing of the standard IRFs.

Moreover, given the evidence regarding the existence of a unit root in the time series under analysis⁸—see Online Appendix A—we estimate, as part of our robustness checks, the following

specification in first differences

$$\Delta y_{t+h} = c + \beta_{h,R(E)}^{+,D} \epsilon_{t,R(E)}^+ + \beta_{h,R(E)}^{-,D} \epsilon_{t,R(E)}^- + \rho_{h,R(E)}^{',D} x_t + v_{t+h,R(E)}^D. \quad (5)$$

In line with the improvements proposed by Stock and Watson (2018), and Piger and Stockwell (2023), we estimate directly the ‘long differences’ of our dependent variables. This specification allows us to estimate the cumulated differences for our IRFs along with their confidence intervals, and requires only changing the left-hand side of equation (5) to express the long differences of the dependent variable, specified as

$$y_{t+h} - y_{t-1} = c + \beta_{h,R(E)}^{+,LD} \epsilon_{t,R(E)}^+ + \beta_{h,R(E)}^{-,LD} \epsilon_{t,R(E)}^- + \rho_{h,R(E)}^{',LD} x_t + v_{t+h,R(E)}^{LD}. \quad (6)$$

The analysis of the asymmetric effects of MP may depend on the specification chosen, and the use of differences would be advisable when unit roots are present. As stated in Kilian and Kim (2011), running a specification in levels in the presence of a unit root is still consistent, though it may carry a biased estimator. Potentially, this bias could be high when working with small samples. In this sense, even when differencing the data may pose certain challenges (see, for example, Gosponidov *et al.* 2013), they should disappear in the presence of non-stationary series, in which case working with differences is more efficient. It has been a generalised and popular practise, however,—as may be observed in recent influential papers, such as those of Tenreyro and Thwaites (2016) and Ramey and Zubairy (2018)—to run the models in log levels, adding a trend to the specification. Hence, in order to provide robust results, we estimate two specifications: a log-level specification augmented with a linear time trend (equation (4)), and a long-differences specification (equation (6)).

Another key aspect to identifying the effects of monetary shocks is to select the proper control variables. Following Tenreyro and Thwaites (2016), the control vector contains three lags (one quarter) of the dependent variable and the federal funds rate. In addition, we also include lags of the MP shock, following the order of autocorrelation suggested by the autocorrelation function (the results are robust to changes in the lag structure). Even if working with a monetary shock should rule out autocorrelation by definition, when focusing on tightening and easing shocks only in recessions or in expansions, the data suggest the existence of autocorrelation (seven lags in both business cycle phases when working with monthly data and the full sample). We also include the information shock of Jarociński and Karadi (2020) as a control, though the results suffer minor changes when we exclude it. As central bank announcements convey information about MP and the economic outlook, ignoring information shocks could bias our responses to monetary shocks. If the central bank surprisingly tightens MP, then interest rates increase, and stock markets fall. A positive information shock, instead, would increase both, given that the tightening could be accompanied by positive information included in the announcement.

Finally, the control vector includes a dummy for the Great Recession period in the full sample estimation and the aforementioned linear time trend in the log-level specification. In order to assess the effect of other macroeconomic variables, we test the effect of including industrial production as a control (three lags, again, in the fashion of Tenreyro and Thwaites 2016). Including industrial production helps to control for supply-side developments that could affect the responses of the markup. In this regard, following Shapiro (2025) and recognizing the role of oil supply shocks in driving inflation dynamics, we also include the oil supply shock from Baumeister and Hamilton (2019). We find that our results remain robust after including these additional controls, and the significance of some responses even improves.

5 | RESULTS⁹

The estimations of equation (4) are reported in Figure 4, where we observe the responses for the three measures of the markup along with the responses of RGDP to the MP shock of Jarociński and Karadi (2020). The responses are calculated to a one-standard-deviation MP shock, both in recessions and in expansions, for the period 1990M2–2016M12. In addition, we also report the responses that are not business-cycle-dependent. A preliminary analysis of our results allows us to identify some important dynamics.

First, it should be noted that in recessions (see the graphs in the middle column of Figure 4), the markup displays a strong increase (decrease) after an MP tightening (easing) shock, just as expected in the NK framework. Indeed, given that output decreases (increases), this implies that the markup responds countercyclically. The increase of RGDP in recessions after an easing is, though modest, significant in the first periods. The responses are similar for the three measures of the markup, peaking at around 50 bps after a tightening, and dropping around 20 bps after an easing. Statistical significance does not seem to constitute a major issue in this specification, with significant responses taking place at several horizons during the first 40 months after the shock, but mostly during the first year.

Second, it may be observed that the behaviour of the markup in expansions (see the graphs in the right-hand column of Figure 4) is clearly procyclical conditional on the MP tightening shock. Indeed, all the measures show a decreasing and mostly significant path for the first 12 months. In the case of easing shocks, the response of the markup is positive, but significance lasts only around six months.

An important result derived from our estimates lies in the fact that monetary shocks would not show high effectiveness in expansions on economic activity (see the responses of RGDP in the right-hand column of Figure 4), especially easing shocks. Instead, in the case of tightening shocks, the significance of the fall partially depends on the specification in the case of RGDP, and it is clear for industrial production, as we will observe in the next subsection.

We also analyse the IRFs when the responses to the shock are not business-cycle-dependent (see the graphs in the left-hand column of Figure 4). In this case, it appears to be clear that the responses are procyclical when it comes to tightening shocks (especially for the baseline measure), but in the case of easing shocks, the responses are clearly non-significant. Overall, while the responses to a tightening shock may be in line with the responses identified by Nekarda and Ramey (2020) and Cantore *et al.* (2021), the responses to an easing shock suggest the need to be cautious with the results reported in those papers.

Our most prominent result is that the dynamics followed by the markup after an MP shock are very different, both in magnitude and in direction, depending on the phase of the business cycle in which the shock takes place. A plausible way to contextualise these results is to compare them with the results of Nekarda and Ramey (2020) and Cantore *et al.* (2021), but bearing in mind that these papers do not consider business-cycle asymmetries, use different MP shocks, and cover different data spans, among other differences. That said, we find that the responses of the markup to a tightening shock in expansions are consistent with the responses found in Cantore *et al.* (2021) for the non-business-cycle-dependent case in terms of direction, but the magnitudes differ: we find a drop of around 40 bps, whereas Cantore *et al.* (2021) report a fall ranging between 10 bps and 20 bps. In addition, our easing shock in expansions displays a similar increase to that of Nekarda and Ramey, of around 20 bps.

In the case of output, we observe from Figure 4 that the maximum fall that suffers in the non-dependent case, of around 50 bps (see the fourth graph in the left-hand column of Figure 4), is also a little higher than that reported by Cantore *et al.* (2021), of around 20 bps. Of course, an issue to consider in these comparisons is that the sample of Cantore *et al.* terminates before the Great Recession, which could naturally lead to a different magnitude of the responses. In

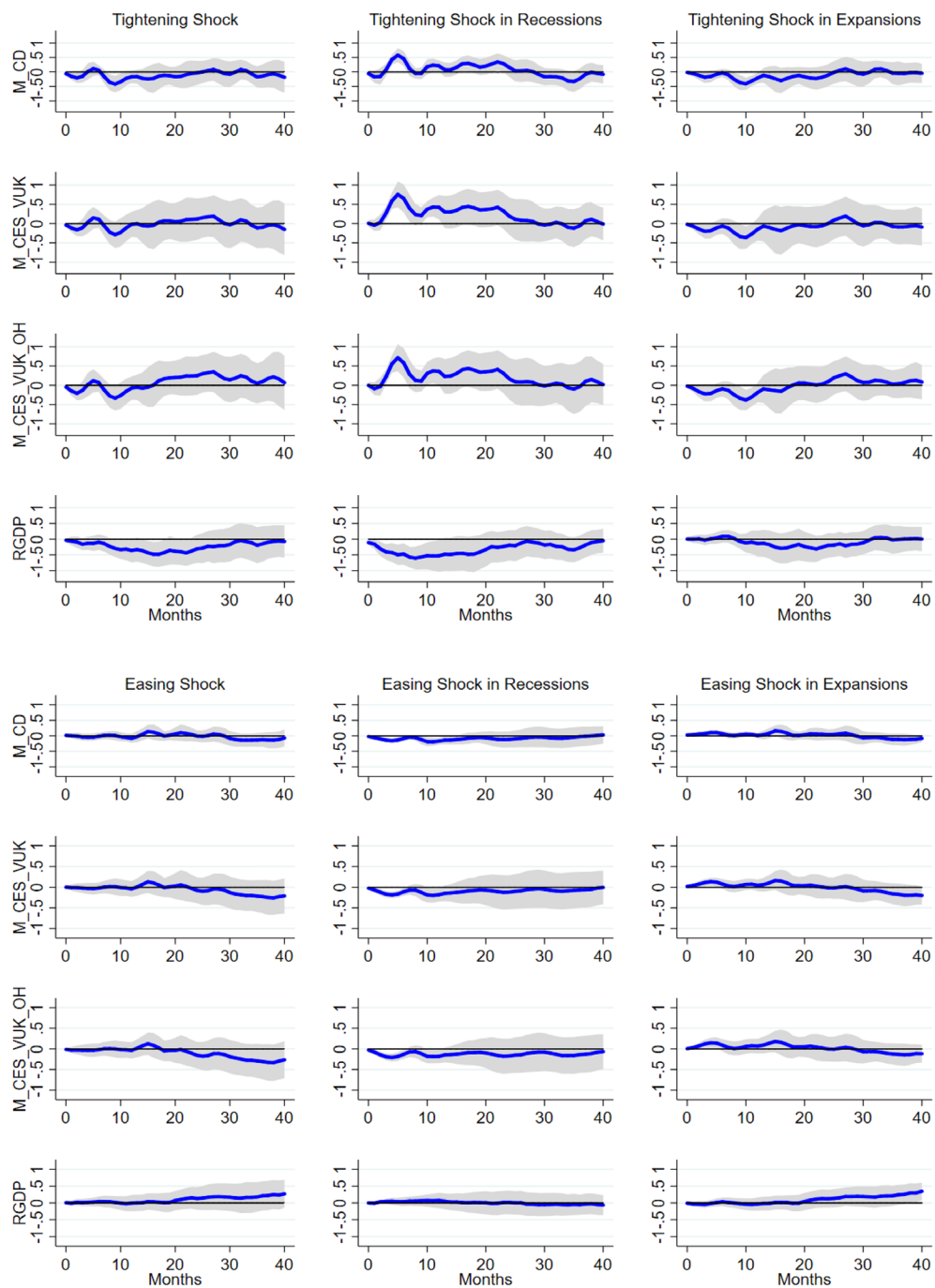


FIGURE 4 IRFs of the markup and real GDP to a one-standard-deviation MP tightening and easing shock—standard LP estimation using a log-level specification augmented with a linear time trend. *Notes:* The figure reports the responses for the first 40 months (the responses multiplied by 100 give the basis points) along with the 90% confidence intervals, estimated using equation (4). We use Newey–West standard errors. The sample covers the period 1990M2–2016M12.

addition, Cantore *et al.* (2021) estimate the responses to a 25 bps increase in the interest rate, while we standardise our shock to one standard deviation.

5.1 | Smooth local projections, long differences, and responses for industrial production

Since the seminal paper of Jordà (2005) a broad literature has come up with refinements and recommendations that could improve the performance of the standard LP estimator. In this subsection, we cover the two main improvements proposed in recent years: the SLP as suggested in Barnichon and Brownlees (2019), and the estimation in long differences, for which a recent case has been made in Piger and Stockwell (2023). The estimations implementing SLP are displayed in Figure 5, while those in long differences are condensed in Figure 6.

A quick look at the IRFs derived from the SLP approach (Figure 5) shows visible gains in efficiency, removing the spikes that are typical in the standard LP approach. Naturally, the results show consistency with our previous estimations, with a clear procyclical response in expansions (see the graphs in the right-hand column of Figure 5) and a countercyclical one in recessions (see the graphs in the middle column of Figure 5). Again, this is especially clear when working with contractionary shocks, given the lack of effectiveness of easing shocks on RGDP. It is worth mentioning that the increase in efficiency when working with SLP comes at the cost of increasing the bias of the estimations. Though this is debated in Li *et al.* (2024), they still rule in favour of SLP.

The results derived from our long-differences specification (Figure 6) bring further robustness to our analysis. The fact that we find evidence to support the hypothesis that the markup follows a unit root process suggests that this estimation should be more efficient. The results confirm the conditional countercyclicality of the markup in recessions (see the graphs in the middle column of Figure 6), with both easing and tightening shocks displaying significant responses, and the conditional procyclicality in expansions (see the graphs in the right-hand column of Figure 6), now with a clear effect of tightening shocks on RGDP. We should note two things: first, as found repeatedly, easing shocks in expansions trigger a non-significant response in output; second, the response of the markup to a tightening in expansions is negative but short-lived, and after the second year it displays a positive (mostly non-significant) response. This positive response, interestingly, disappears in our specification including additional controls (see Figure B4 in the Online Appendix).

Finally, in Figure 7, we present the responses of industrial production to both tightening and easing shocks in recessions (middle column) and expansions (right-hand column), and for the non-cycle-dependent case (left-hand column). These results help us to validate the responses obtained from our interpolated RGDP series. Indeed, we observe a sharp decrease in industrial production after a tightening shock in all cases, while easing shocks, although more subtle, display a positive response in recessions and in the non-cycle-dependent case. The only non-significant response that we find is that of easing shocks in expansions, which we observe recurrently in all specifications.

6 | ROBUSTNESS CHECKS

To confirm that the response of the markup to an MP shock is robust, we carry out a battery of robustness checks. We report the results of these checks in Online Appendix B. In particular, the response of the markup is robust to all the checks listed below.

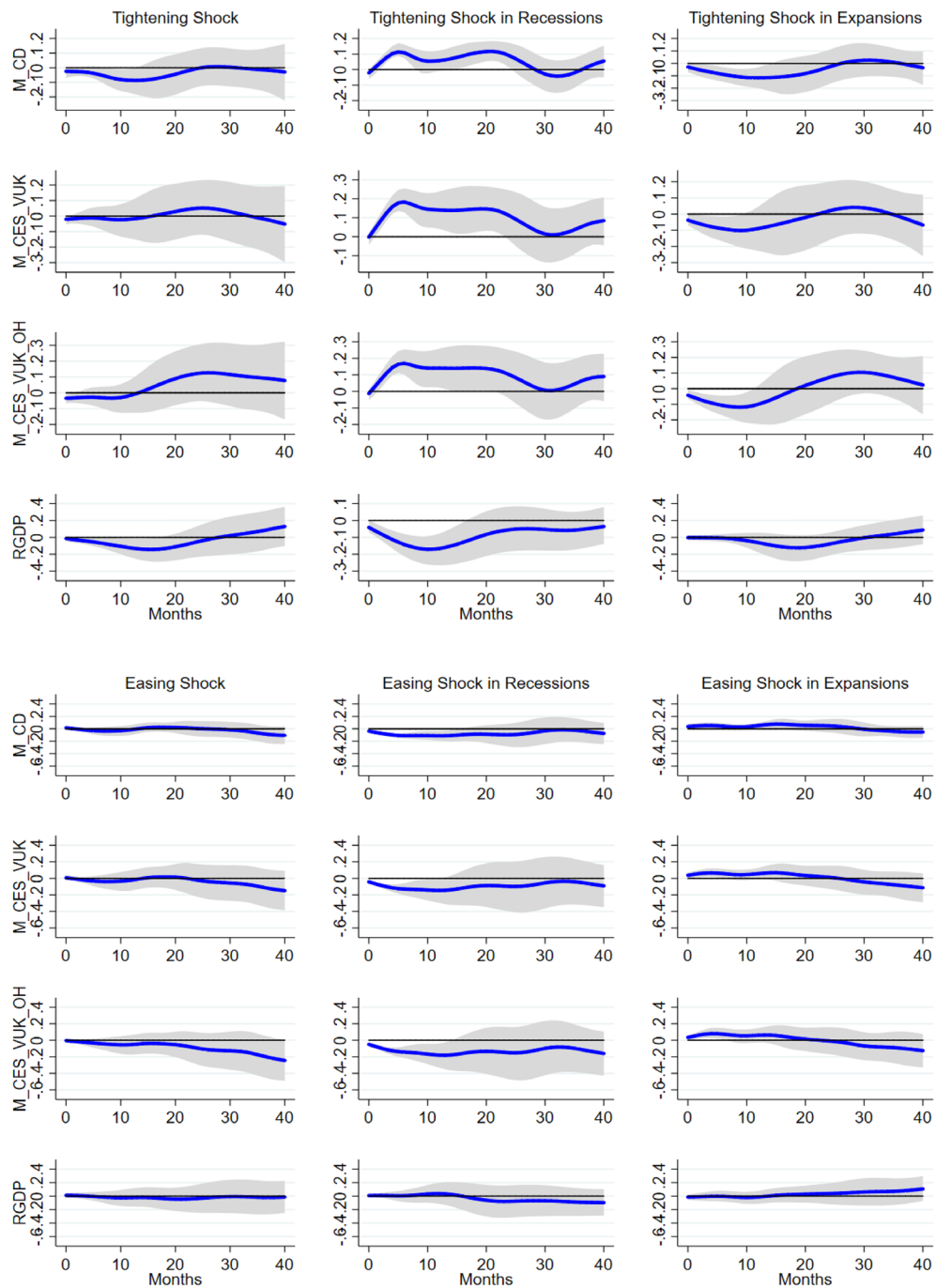


FIGURE 5 IRFs of the markup and real GDP to a one-standard-deviation MP tightening and easing shock—smooth LP estimation using a log-level specification augmented with a linear time trend. *Notes:* The figure reports the responses for the first 40 months (the responses multiplied by 100 give the basis points) along with the 90% confidence intervals, estimated using equation (4). The IRFs are smoothed following the SLP approach of Barnichon and Brownlees (2019). The sample covers the period 1990M2–2016M12.

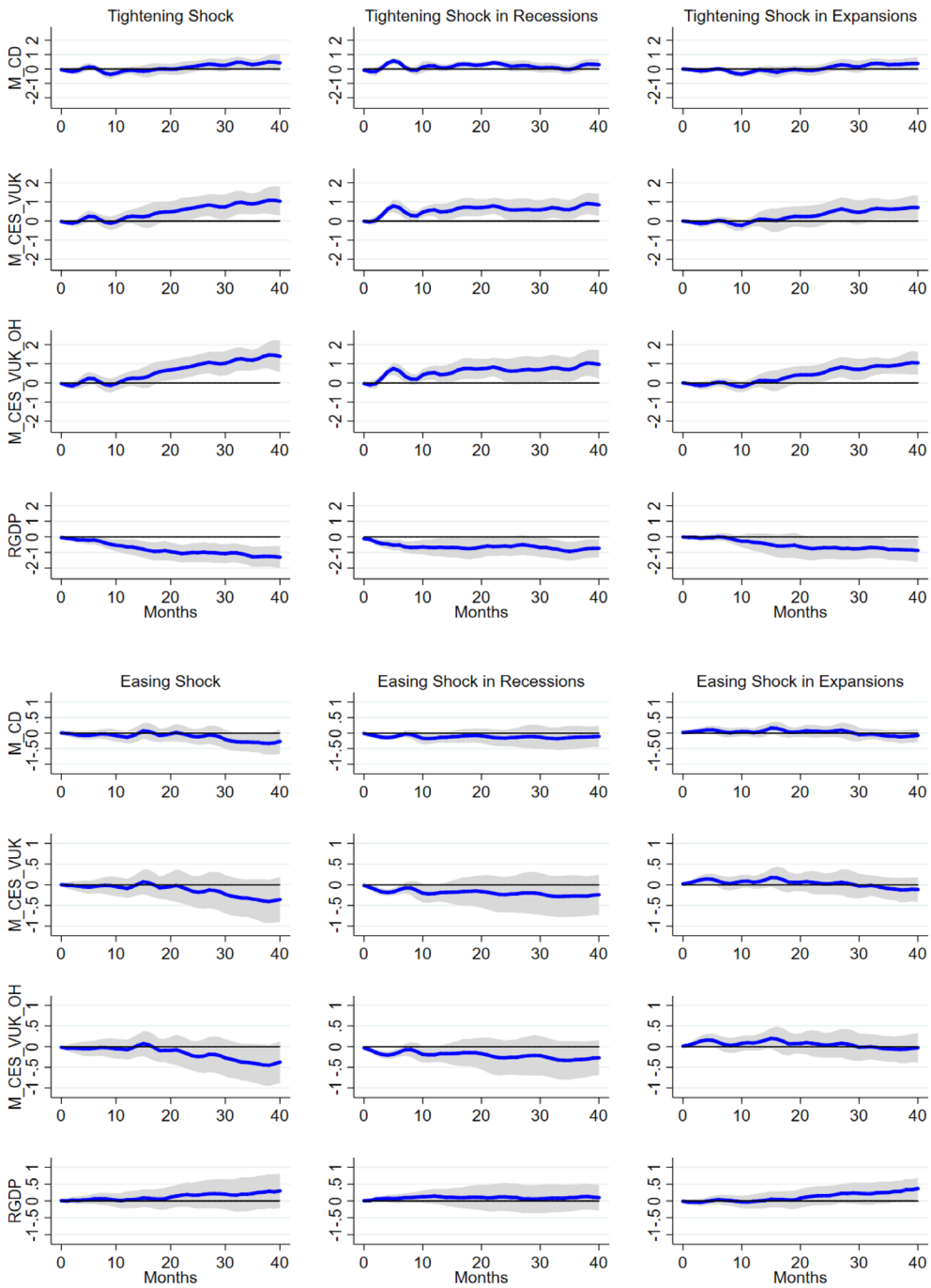


FIGURE 6 IRFs of the markup and real GDP to a one-standard-deviation MP tightening and easing shock—standard LP estimation using a long-differences specification. *Notes:* The figure reports the cumulated responses for the first 40 months (the responses multiplied by 100 give the basis points) along with the 90% confidence intervals, estimated using equation (6). We use Newey–West standard errors. The sample covers the period 1990M2–2016M12.

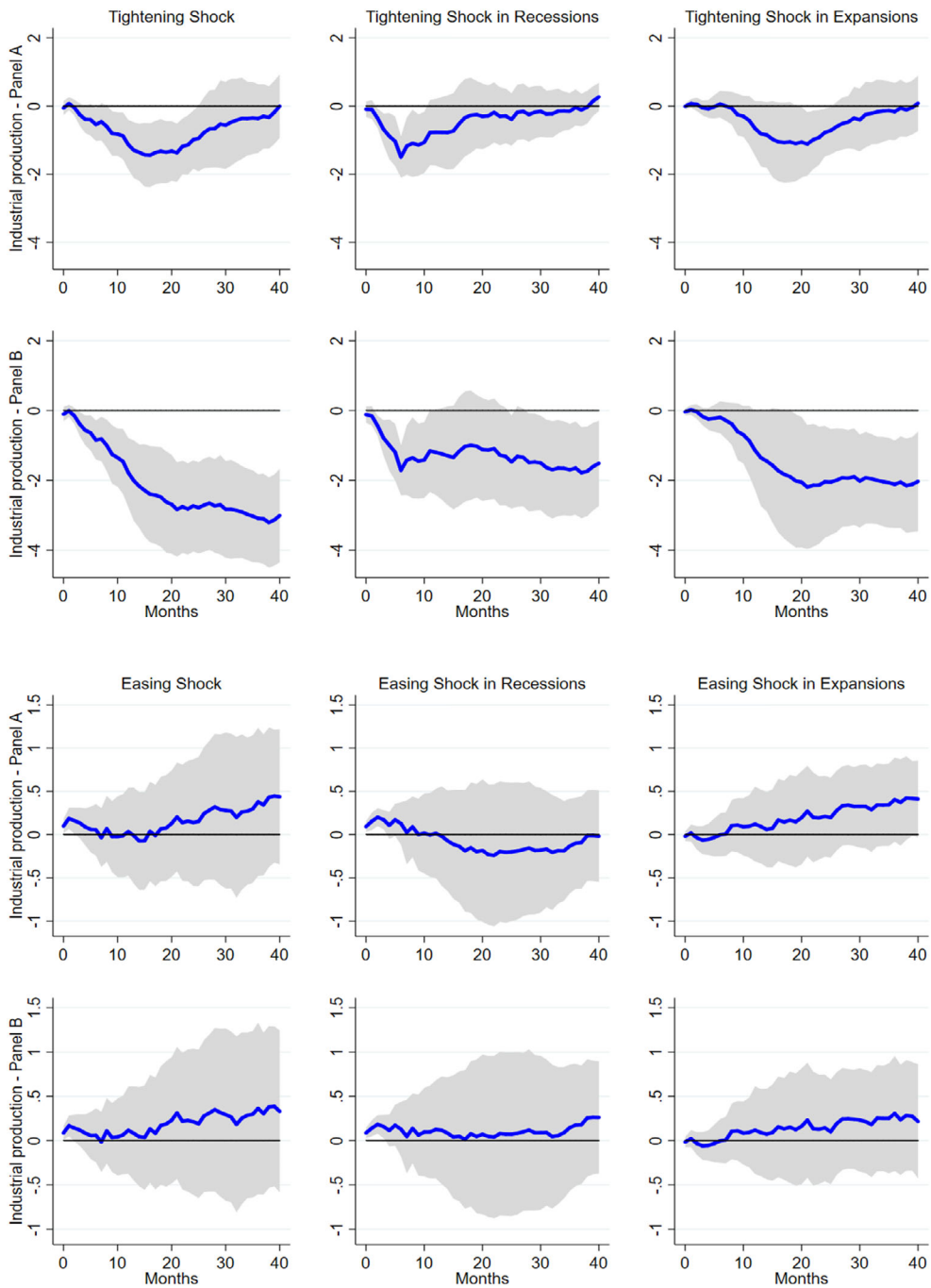


FIGURE 7 IRFs of industrial production to a one-standard-deviation MP tightening and easing shock—standard LP estimation using a log-level specification augmented with a linear time trend (panel A) and a long-differences specification (panel B). *Notes:* Panel A reports the responses for the first 40 months (the responses multiplied by 100 give the basis points) along with the 90% confidence intervals, estimated using equation (4). Panel B reports the cumulated responses along with the 90% confidence intervals, estimated using equation (6). We use Newey–West standard errors. The sample covers the period 1990M2–2016M12.

6.1 | Data span

Since the data span, covering the period 1990M2–2016M12, included the Great Recession and the zero lower bound period, we also estimate a subsample stopping at 2007M12 (see Figure B1 in the Online Appendix). It is important to mention that since the estimations resort to the MP shock of Jarociński and Karadi (2020), they are not subject to the critique of Basu and House (2016) and Ramey (2016). In these papers, they point out that when using samples with more recent data, the IRFs change radically in comparison to those estimated by Christiano *et al.* (2005), for which they employ older data. A possible reason for this could be that the quantitative easing programme in response to the Great Recession has made it more difficult to properly identify MP shocks. Additionally, it may be noted that stopping the series before 2007 heavily reduces observations, which may increase the bias of our estimator, especially in recessions. This is the reason behind the sharp response experienced in recessions (in particular after a tightening). However, we consistently achieve significant responses and the same signs when compared to the findings using the full sample.

6.2 | Data frequency

We complement the estimations performed using monthly interpolated data with quarterly data. When using quarterly data (see Figure B2 in the Online Appendix), we document that the responses to a tightening shock in recessions take around two quarters to become positive, and then they display a sharp upward dynamic. Instead, the responses in recession to an easing shock display an immediate negative response. In expansions, the responses are as expected, decreasing after a tightening, and increasing after an easing.

6.3 | Stochastic trends

Since the evidence suggests the existence of unit roots in all the series under analysis (see Online Appendix A), we complement the estimation in log levels with an estimation in long differences, the findings of which are discussed at length in Subsection 5.1.

6.4 | Controls

Several sets of control variables have been tested. In particular, we include lags of the MP shock following the order of autocorrelation suggested by the autocorrelation function. In addition, the information shock of Jarociński and Karadi (2020) has been included in all the estimations, though by removing it, only minor changes were experienced. Moreover, following Tenreyro and Thwaites (2016), lags of the dependent variable and the federal funds rate were also included as controls (one quarter, three lags). Furthermore, a dummy for the Great Recession period was included in the full sample estimation, and a linear time trend in the log-level specification. Our results are robust to changes in the lag structure of explanatory variables and to the inclusion of additional controls. For instance, with the aim of controlling for possible innovations originating in the supply side of the economy, we include additional controls, such as industrial production and oil supply shocks. Our results remain robust after adding the new controls and significance even improves in some cases (see Figures B3 and B4 in the Online Appendix). As found in Shapiro (2025), oil supply shocks impact inflation, and controlling for them reduces the chances that supply shocks could be driving our responses of the markup.

6.5 | Dependent variables

Our results are robust to the use of proxy measures for the markup. Due to data frequency issues, it is not possible to produce our estimates using firm-level data—for example, the markup estimated in De Loecker *et al.* (2020) is available only at an annual frequency. Instead, we exploit the close relationship between the markup and profits to propose an alternative approach. Interestingly, as Broer *et al.* (2020) note, the countercyclical response of the markup in the NK model is also associated with the response of profits, which also react countercyclically. Hence, we proxy the markup using two series of corporate profits per unit of real gross value added in the non-financial corporate sector, sourced directly from the Federal Reserve Bank of St Louis, one after taxes,¹⁰ and the other before taxes.¹¹ Notably, we find strong correlation coefficients, of around 0.8, between our proxy measures and the markup estimated by De Loecker *et al.* (2020) (at annual frequency). This is unsurprising, since the strategy to estimate the markup with firm-level data is based on data on the costs of goods sold and revenues, and by construction, to estimate profits, both revenues and costs are needed. The responses of our proxy measures are consistent across all scenarios, with profits decreasing (increasing) conditional on a tightening (easing) shock, and tightening (easing) shocks triggering an increasing (decreasing) response in recessions and a decreasing (increasing) response in expansions (see Figure B5 in the Online Appendix). In the case of tightening shocks in recessions, the markup increases sharply on impact, displaying an erratic response thereafter.

7 | DISCUSSION

Our results suggest that the dynamics of the price markup conditional on an MP shock are asymmetric, displaying a countercyclical response in recessions, and a procyclical one in expansions. This implies that the markup behaves as expected in the NK framework only during recessions. These asymmetries could be grounded in several different factors, such as, for example, prices being stickier in recessions. An interesting literature supports the idea that downward rigidity is higher in recessions (see, for example, Daly and Hobijn (2014), on wage rigidities). In such scenarios, with aggregate demand and prices already weak, a tightening shock might not push prices down. If we face upward rigidity as well, then an easing shock could increase demand but not prices, perhaps because firms would delay price adjustments until recovery is confirmed.

Additionally, some influential papers allow us to contextualise that the countercyclicality of the markup in recessions could arise from the decision of firms to preserve liquidity after a negative demand shock, setting higher markups (see Gilchrist *et al.* 2017). Instead, the negative response of the markup after a tightening in expansions would stem from firms prioritising market shares over margins. Evidently, decisions on margins would be related to firm entry dynamics, known to be procyclical, and firm exit, whose countercyclicality is somehow more discussed (see, for example, Tian 2018) but with net exit being typically negative only in downturns, and having the potential to produce asymmetric business-cycle dynamics (Bernstein *et al.* 2021). Indeed, the possibility of setting higher markups after a tightening in recessions would be reinforced by the fact that net firm entry would be negative in downturns and even more affected after the negative demand shock, increasing market concentration. Setting lower markups would not be an option in times of financial constraints, and the only available scenarios would be to either set high markups or leave the market. On the contrary, an easing shock in recessions would increase output, ease financial restrictions, and encourage firm entry or reduce net exit, increasing competence and reducing margins. In expansions, tightening shocks would reduce output but margins would not increase, since firms would pursue a defensive strategy, reducing margins to keep the market share. This strategy would help them to remain in the market. Though net entry could

decrease, it would still be positive in expansions since, as Bernstein *et al.* (2021) suggest, net entry would be negative only in recessions.

The evolution of firm entry and the existence of firm heterogeneity are essential to understanding the dynamics and challenges that could lie behind our results. Indeed, recalling that the markup explains the difference between the price a firm charges and its marginal cost, the concept has microeconomic foundations relating to market structure and firm behaviour. Under monopolistic competition with free entry, a firm can charge a high markup over marginal cost while still earning zero economic profit in the long run. This happens because new firms enter the market, increasing competition and reducing the market share of each individual firm until economic profits are driven down to zero. The markup in this context does not necessarily indicate economic profit, as it reflects the pricing power of firms over production costs. Yet if markups and profits are positively related, then it suggests that there are barriers to entry that prevent new firms from entering the market and eroding profit margins. These barriers could include high startup costs, regulatory constraints, or established brand loyalty, which shield existing firms from competition, allowing them to maintain both high markups and sustained profits. Therefore, while markups might appear to represent profit margins, they do not translate into profitability unless barriers to entry are in place. This discussion is vital for us, given that we find similar results when estimating the responses for both the markup and our proxy measures (based on profits).

Furthermore, even with an ongoing debate on whether larger firms tend to charge higher markups (see, for example, Mertens and Mottironi 2023), firm heterogeneity may complicate the assessment of markups at an aggregate level. It is a clear possibility that larger firms could benefit from economies of scale and have greater control over their supply chains, allowing them to reduce costs and set higher prices relative to smaller firms. This suggests that firms across the size and productivity spectrum will respond differently to economic shocks. For example, a large, productive firm may adjust its markup only minimally in response to a cost shock, passing it on to prices, while smaller firms with less pricing power may adjust markups significantly. Consequently, aggregate markup measures may mask these underlying differences, making it difficult to predict how an economic shock will impact the broader economy. These heterogeneous responses highlight the challenges of using aggregate markups as indicators of market performance, and complicate the effectiveness of policy interventions aimed at influencing pricing behaviours across different types of firms.

Finally, the markup dynamics could be driven by the dynamics of productivity, prices and wages in the labour market, or the different adjustment of expectations to the shock. Consider the baseline measure of the markup, as presented in Nekarda and Ramey (2020) and also analysed in Cantore *et al.* (2021), defined as the inverse of the labour share and given by

$$\text{price markup} = \frac{P * Y}{W * L}, \quad (7)$$

where the numerator represents value added, and in the denominator, W accounts for nominal wages and L for labour hours. Evaluating our results through the lens of equation (7) allows us to deduce further the implications of the asymmetries observed in the results. Focusing first on tightening and easing shocks in recessions, a tightening shock in recessions would certainly reduce output and labour hours, but if we face downward rigidity, then prices and wages would remain fixed. Consequently, we need hours to fall more than output to yield a positive response in the markup, which would trigger an increase in productivity (given by the ratio Y/L). This suggests that there could exist a composition change of the workforce, a phenomenon widely studied in economics (see, for example, Bils 1985; Solon *et al.* 1994; Elsby *et al.* 2010), by which the less productive workers are driven out of the labour market in recessions, with firms keeping the most

productive workers in the labour force. Even if this composition effect has been proposed as one of the explanations for the productivity increase during the Great Recession, Lazear *et al.* (2016) suggest that composition effects might not be the only or the most important drivers of the boost in productivity during recessions, since workers may also be inclined to work harder during the downturns—the so-called *making do with less* effect. In summary, both the composition effect and the making do with less effect would be reinforced after a tightening that worsens the recession, triggering our increasing response in the markup.

Alternatively, easing shocks during recessions would directly affect output and hours, with two main possibilities emerging. First, the reduction in the markup could result from hours increasing more sharply than output, suggesting a rapid unwinding of the composition effect. This would involve low-productivity employees being reincorporated into the market, and labour hours exhibiting high elasticity. Second, relaxing the assumption on price and wage rigidity (now we are referring to upward rigidity) could imply that the response of the markup rests on the fact that prices are stickier than wages. This idea would be in line with the derivations of Nekarda and Ramey (2020), where they suggest that the whole analysis on the conditional cyclicity of the markup could benefit from a new focus on wage rigidity.

Now, considering monetary shocks in expansions, and as our results show that easing shocks do not appear to be effective in expansions, we place the emphasis on tightening shocks. If output falls as expected together with labour hours, then a procyclical response should likely be rooted in the behaviour of firms prioritising market shares over profit margins, a natural behaviour in booms (see Gilchrist *et al.* 2017). In simple words, as the economy cools down after the shock, firms try to maintain the volume instead of adjusting margins. In addition, a similar procyclical behaviour could arise if prices were more flexible than wages.

An alternative angle to frame our results could derive directly from the NK framework itself. As Cantore *et al.* (2021) state, in the baseline dynamic stochastic general equilibrium model, the expression for the markup could be retrieved from the NKPC

$$\frac{1}{mc_t} = \frac{k}{\pi_t - \beta E_t \pi_{t+1}}, \quad (8)$$

where mc_t is real marginal costs (and $1/mc_t$ represents the price markup), β is the discount factor, π_t and $E_t \pi_{t+1}$ are inflation and inflation expectations, and k gives us the slope of the NKPC.

From equation (8), a new perspective comes into play with the introduction of expectations. Indeed, the cyclicity of the markup conditional on an MP shock could be directly linked to the effectiveness of MP to shape inflation expectations. For instance, considering monetary shocks in recessions, increasing markups after a tightening suggest that either inflation falls or at least the effect on inflation is higher than the effect on inflation expectations. After an easing, we should face the exact same situation, with inflation reacting to the shock (positively) but expectations reacting relatively less. In expansions, instead, expectations should be less sticky than actual inflation. For instance, if after a tightening, prices reacted downwards, then a fall in the markup would arise only if expectations were adjusted downwards even further.

When looking at our results through the lens of the NKPC, some warnings should be made. On one hand, we should note that in the NK model, the slope k is a decreasing function of the level of stickiness, and this should not be linear across business cycle phases. On the other hand, since our findings suggest that inflation should be more (less) responsive than expectations in recessions (expansions), this appears to be at odds with the higher rigidity in recessions that we have been advocating in general. This suggests, as Cantore *et al.* (2021) propose, that either the labour share is not a good proxy for the markup, or the NKPC struggles to explain inflation dynamics. Finally, in equation (8), recall that in the NK model, inflation in period t and inflation expectations are not independent one from another. Galí (2015) shows that in a baseline NK model, π_t can be expressed as the discounted sum of current and expected deviations from a steady

state markup, and π_t could be high (low) because firms that have the chance to adjust prices, expecting lower (higher) markups in the future, set a price above (below) the economy's average price level.

Taken together, our findings unveil a set of transmission mechanisms at play with the potential to trigger a countercyclical (procyclical) response of the markup in recessions (expansions). These leads provide a wide set of drivers to consider when assessing the effects of monetary shocks, ranging from the effect of shocks on prices, wages, labour hours and output, to at least two potential interesting foci of analysis that we could frame in terms of 'sticky prices versus sticky wages' and 'sticky prices versus sticky expectations'.

8 | CONCLUSIONS

We examined whether the response of the markup conditional on a monetary policy (MP) shock depends on the phase of the business cycle in which the shock occurs. The markup constitutes a key variable in the framework of the New Keynesian (NK) model, and its expected countercyclical behaviour conditional on an MP shock is an essential channel through which these models operate. Indeed, proponents of the NK model rely on this transmission mechanism in order to reduce inflation pressures after a policy tightening.

Though still scarce, the analysis of the dynamics of the markup conditional on an MP shock has made some important progress in recent years, with Nekarda and Ramey (2020) and Cantore *et al.* (2021) being the most prominent references in the literature, and ruling in favour of a procyclical behaviour. However, these papers do not consider the possibility of asymmetric markup responses triggered by the fact that shocks take place at different phases of the business cycle. The aim of our research was to bridge this gap using the local projections approach à la Jordà (2005), the smooth local projections approach of Barnichon and Brownlees (2019), and the empirical strategies developed in Tenreyro and Thwaites (2016) and Funashima (2022).

Our main finding is that the response of the markup to an MP tightening (easing) shock during the period 1990M2–2016M12 has been asymmetric, decreasing (increasing) in expansions, and increasing (decreasing) in recessions. Since RGDP falls (increases) after the tightening (easing) shock—with the caveat that easing shocks in expansions do not seem to affect output—the empirical analysis carried out in this study suggests that the response of the markup is procyclical in expansions, as expected in Nekarda and Ramey (2020) and Cantore *et al.* (2021), and the opposite to that expected in the NK framework. The response in recessions is as expected in the NK model—countercyclical. These results seem to suggest that the NK model cannot reconcile theory with the empirical evidence, at least not in normal times.

Moreover, these results cast doubts regarding the transmission mechanisms of MP in expansions. The increase of interest rates in periods of booms would not reduce inflation, at least not through the transmission mechanism derived from the increase of the markup and, naturally, profits. The asymmetric responses of the markup to MP shocks over the business cycle carry important policy implications. As the results suggest that typical interest rate tools may be less effective in expansions, policymakers will need to consider other alternatives, such as macroprudential policies to regulate financial flows from institutions to firms, and sector-specific interventions to influence inflation and output. Moreover, the results imply that the Federal Reserve could adopt asymmetric policy frameworks, adjusting strategies based on the business cycle phase. A flexible approach to MP that is sensitive to the phase of the business cycle could improve its efficacy in managing inflation and stimulating growth.

The responses are robust to all the measures of the markup tested, all model specifications, and a subsample truncated before the Great Recession. The subsample estimations may be of interest, since they allow positing some ideas for future work regarding how including the Great Recession and the zero lower bound period may affect the results.

Much work is still needed to enrich this strand of the literature, constituting the contributions of this paper to be a step in such a direction. Future research may consider different empirical identification strategies to estimate the response of the markup, different measures of the shock, different asymmetries, periods or countries, firm entry dynamics and financial frictions, among many other leads of work.

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ENDNOTES

- ¹ See <https://fred.stlouisfed.org/series/gdpcl> (accessed 17 April 2025).
- ² See <https://www.bls.gov/opub/mlr/2017/article/estimating-the-us-labor-share.htm> (accessed 24 April 2025).
- ³ Note that our baseline measure coincides with that of Nekarda and Ramey (2020), since both are estimated in the same way. The markup estimates of the latter constitute the state-of-the-art measures calculated using macroeconomics data. Though it would seem appealing, due to data frequency issues it is not feasible to perform our estimations using firm-level data, as that estimated, for example, by De Loecker *et al.* (2020). However, as robustness, we provide the estimates for proxy measures for the markup working with data on profits in the non-financial corporate business sector.
- ⁴ Note that the interpolation results for RGDP and the different markup measures are robust to the use of different input variables, such as industrial production and unemployment.
- ⁵ See <https://fred.stlouisfed.org/series/USREC> (accessed 17 April 2025).
- ⁶ The specification of equation (3) is equivalent to estimating $y_{t+h} = c + \beta_{h,R}\epsilon_{t,R} + \beta_{h,E}\epsilon_{t,E} + \rho'_h x_t + u_{t+h}$, where the shock has already been decomposed, the control vector is the same across business cycle phases, and $\epsilon_{t+h}^{mp} = \epsilon_{t,R} + \epsilon_{t,E}$.
- ⁷ Note that there is one equation for each business cycle phase denoted by $R(E)$.
- ⁸ This non-stationarity in the markup, for instance, is also found in measures calculated with an industry-based model, as in Kim (2010).
- ⁹ The full dataset, Stata and Matlab replication files can be retrieved from the repository <https://github.com/nicolasblampied/Asymmetric-markup-responses-to-monetary-shocks-over-the-business-cycle---Replication-Package> (accessed 17 April 2025).
- ¹⁰ See <https://fred.stlouisfed.org/series/A466RD3Q052SBEA> (accessed 17 April 2025).
- ¹¹ See <https://fred.stlouisfed.org/series/A463RD3Q052SBEA> (accessed 17 April 2025).

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