BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

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April 2020

Number 1275

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The papers published in the Temi di discussione *series describe preliminary results and are made available to the public to encourage discussion and elicit comments.*

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ISSN 1594-7939 (print)
ISSN 2281-3950 (online)

Printed by the Printing and Publishing Division of the Bank of Italy

MONETARY POLICY GRADUALISM AND THE NONLINEAR EFFECTS OF MONETARY SHOCKS

by Luca Metelli[*], Filippo Natoli[*], Luca Rossi[*]

Abstract

Monetary policy in the United States has often followed a gradual approach by changing policy rates through multiple small adjustments rather than all-at-once hikes or cuts. This conduct could provide a signal about the extent of the intended policy change. We quantify the state-dependent effects of monetary shocks in times of more and less gradual policy. We propose two indicators of high vs. low gradualism periods and use local projections to estimate the effects of identified high-frequency shocks in the two states. Our findings suggest that monetary policy transmission is stronger when the perception of gradualism is high.

JEL Classification: C22, C26, E44, E52, E58.
Keywords: gradualism, inertia, monetary policy transmission, state dependence, local projections.
DOI: 10.32057/0.TD.2020.1275

Contents

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1 Introduction[1]

Statements and speeches by the Federal Reserve (Fed) are analyzed in great detail by market participants, who struggle to interpret Fed's thinking. Also, markets infer future Fed moves from the way it adjusts the target interest rate. Changes in policy rates have often been implemented through a sequence of small and gradual adjustments in the same direction, diluted over a period of months, rather than through abrupt one-off hikes or cuts. This monetary policy conduct, defined as inertia or gradualism, reveals information that markets try to interpret and to which they can, potentially, react.

The inertial feature of monetary policy has long been studied and debated. Much of the academic work has focused on two main issues. On the one hand, the literature has investigated empirically the potential presence of inertia in the central bank reaction function. On the other hand, some papers have looked for rationales to explain why the optimal monetary policy might incorporate a certain degree of inertia. In this paper we study monetary policy gradualism from a different perspective, focusing on its implications for the transmission of monetary shocks. The paper asks the following questions: is the degree of gradualism time varying? Does a gradualist signal influence the transmission of monetary policy? Does gradualism have relevant macroeconomic implications?

To answer these questions, we investigate possible state-dependent effects of monetary policy shocks in times of more and less gradual policy. For this purpose, we propose two indicators of high vs. low gradualism periods and use local projections with instrumental variables (LP-IV) to estimate the effects of high-frequency identified shocks in the two states. We find that shocks occurring in periods in which the perception of gradualism is high produce larger effects than in normal times. In high gradualism states, the

[1] We are indebted with Luca Missori for excellent textual analysis. We also thank Alessio Anzuini, Marco Bernardini, Francesco Caprioli, Valerio Ercolani, Andrea Finicelli, Andrea Gazzani, Giuseppe Parigi, the participants in the 2019 Midwest Macroeconomic Meetings and two anonymous referees for their helpful comments and suggestions. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank of Italy. All the remaining errors are ours. E-mail: luca.metelli@bancaditalia.it, filippo.natoli@bancaditalia.it, luca.rossi@bancaditalia.it.

transmission of shocks is significantly larger on government interest rates, both in the case of short- and long-term yields; a stronger reaction, although less pronounced, is also visible on some interest rate spreads (such as the excess bond premium and the commercial paper spread) and macro variables (CPI inflation and the real effective exchange rate of the dollar). To the best of our knowledge, no previous evidence exists regarding the empirical effects of gradualism on the transmission of monetary policy shocks.

Our paper is constructed as follows. First, we provide evidence on the time variation of the degree of gradualism in the conduct of monetary policy during the 1990s and the 2000s, using both anecdotal and empirical evidence from estimated Taylor rules. Second, we construct an indicator to define states of high and low perceived gradualism. The indicator identifies periods of high perceived gradualism as those in which the Fed increases/decreases the target interest rate several times by the same amount (25 basis points) and in the same direction in consecutive FOMC meetings. The intuition is that, if investors learn from recent policy moves, a series of sequential moves in the same direction eventually lead them to adjust their beliefs for the near future accordingly. The rationale relies on statements made by Alan Greenspan during his chairmanship, as explained in Section 4.2. As a robustness check, we construct two further indicators of gradualism. The first one is a slight variation of the baseline, in which periods of high gradualism are identified as those in which one observes sequential moves of the policy rate in the same direction of *any* size. The second one is based on the fact that the Fed *directly* communicates to the markets, in statements and speeches, its intention of being gradual. Using the Dow Jones Factiva tool, we count the number of articles in which terms related to the Fed are meaningfully coupled to those on gradualism, and consider months with a high gradualism perception by the markets as those in which the media coverage is high. Third, we separately estimate the effect of exogenous monetary policy shocks in periods of high and low gradualism, as defined by the indicators described above. Shocks are identified by means of high-frequency surprises in Federal funds futures, as it is standard in the monetary policy literature. According to our baseline estimates, the transmission in the two states is significantly different especially in the first 12 months after the shock. Concerning bond yields, the difference is largest after 9 months; results are confirmed, especially for interest rates, using the alternative indicators, although the stronger impact in the high state is more delayed. For both short and long-term government yields, the response in the high gradualism state is five times larger than that in the low state in the baseline estimate. In that state, the commercial paper spread and the excess bond premium also react more, the former in the short term while the latter in the longer run. Concerning macro effects, the differential response between the high vs. low gradualism state is significant for inflation but not for industrial production.

Our results are in line with the theoretical predictions of Woodford (2003) and Stein and Sunderam (2018), which propose models in which this signal is either intended or unintended. According to Goodfriend (1991) and Woodford (2003), the Fed uses gradualism to affect market expectations on future short rates and to influence long-term rates, which are relevant for economic activity. On the contrary, Stein and Sunderam (2018) assume that the Fed has some private information regarding the optimal target interest rate and is averse to bond volatility. In the latter case, if the Fed uses gradualism to avoid spooking the market, it may, nonetheless, fail in this endeavor and de facto provide the same signal: indeed, markets may realize that the Fed underplays its desire to make a larger policy change, and react accordingly.

This paper contributes to the literature in the following ways. First, we provide empirical evidence of the relevance of the signaling role of monetary policy. While most of the related literature focuses on the so-called *information content* of monetary policy, i.e. the signaling regarding the (unknown) state of the economy, here we study an additional signal, which directly depends on policy implementation and informs on future central bank moves. Second, we contribute to the literature on gradualism, showing that inertia is not a constant feature of monetary policy and highlighting that such conduct is relevant for the transmission of monetary shocks to the economy. It is important to point out that the rationale behind the type of gradualism that we study in this paper is different from the one behind the gradualist behavior observed in the most recent period. Indeed, the type of gradualism we are referring to relates to the *strategy* of diluting interest rate changes over time; by contrast, the use of the term gradualism related to the 2015-2019 tightening phase should be interpreted more as the cautious, *wait and see* attitude of the Fed in raising interest rates. The paper also highlights the relevance of the strategy itself in the implementation of monetary policy. We focus on the monetary shocks occurred in the 1990s and mid-2000s, a period in which forward guidance was not explicit and market uncertainty on future policy decisions was pronounced. Both gradualism and forward guidance send signals about the future path of interest rates, but they do so in different ways: while forward guidance steers expectations through central bank communication, the gradualist signal is inferred from actual moves of the policy rate. For this reason, in periods in which the Fed communicates its future intentions using forward guidance, the signaling power highlighted in our paper could be lower, as markets are more informed about medium term policy changes; however, when there is high uncertainty or disagreement around the guidance itself, gradualism could still play a role as an alternative and complementary signal about future monetary policy moves.

Literature review

This paper draws on different strands of literature. First of all, we relate to the broad literature on the signaling effects of monetary policy, both empirical and theoretical. Romer and Romer (2000) document empirically how monetary policy actions can reveal to the market part of the Fed's superior information regarding inflation. By contrast, Jon et al. (2004) find little evidence that Fed policy surprises convey additional information about the state of the economy. More recently, Nakamura and Steinsson (2018), Miranda-Agrippino and Ricco (2017) and Jarocinski and Karadi (2018) all study, in different ways, the information content of monetary shocks. These papers investigate the signal extraction process of market participants, focusing on the information content of monetary policy regarding the state of the economy, over which the central bank is assumed to have superior information. Differently, in our paper we focus on the signaling role of the Fed strategy itself, which conveys information concerning the unknown future optimal level of the target interest rate. In this sense, we are also closer to the literature investigating the effects of forward guidance, like Campbell et al. (2012), Krishnamurthy and Vissing-Jorgensen (2011). Regarding the theoretical literature on the signaling role of monetary policy, early contributions are Cukierman and Meltzer (1986) and Ellingsen and Soderstrom (2001), while the most recent ones include Melosi (2017), Berkelmans (2011), Tang (2013), Andrade et al. (2015).

Moreover, our paper relates to the literature on monetary policy gradualism. This literature delved into analyzing whether interest rate smoothing actually characterizes central banks behavior. Sack (2000) and more recently Coibion and Gorodnichenko (2012) and Campbell et al. (2015) document how the Federal Reserve in the US follows an inertial behavior in interest rate setting, while Clarida et al. (1998) present similar evidence for other central banks around the world. By contrast, Rudebusch (2006) argues that the inertial behavior of the Fed identified by previous work is merely due to the persistency of the shocks affecting the economy, which the Fed is responding to. Other papers, like Consolo and Favero (2009), reach similar conclusions. Bernanke, surveying the literature in 2004, concluded that the question remains unsolved (Bernanke, 2004). A possible interpretation of such mixed evidence is that the interest rate smoothing behavior is time varying, being present only in certain periods and not in others. Possible explanations for such time variations are related to changes over time in central banks preferences and prevailing economic theory, the changing composition of FOMC members or different Fed's strategies. In the paper we show how this is the case for the US and we develop two indicators to measure the perceived degree of policy inertia over time.

From a normative point of view, one possible reason for the presence of inertia in the reaction function of the central bank relies in the uncertainty surrounding the effects of monetary policy. In his seminal contribution, Brainard (1965) argued that when policymakers are uncertain about the quantitative effect of a given interest rate change, acting gradually may reduce economic instability and enhance the expectations channel of monetary policy. Ferrero et al. (2019) conduct an analysis of the Brainard principle in terms of optimal monetary policy, and conclude that the optimality of a gradual approach depends on the occurrence of more or less persistent shocks to the economy. Another rationale for policy gradualism is the following. Based on the intuition of Goodfriend (1991), Woodford (2003) explains that the inertial behavior could be motivated by the fact that the Fed wants to steer long-term interest rates, which are the rates households and firms respond to. In Woodford's model, it is desirable for the Fed to underadjust the policy rate if, when it moves gradually, the markets understand that this policy is going to persist: in this case, a small adjustment in short rates can deliver significant effects on long-term ones, as long rates incorporate current and expected future short term interest rates, producing greater macroeconomic effects without generating excessive short-term volatility. By contrast, Stein and Sunderam (2018) propose a model in which the gradualist approach produces suboptimal policy responses. They assume that the Fed has superior information about its desired target interest rate and is averse to bond market volatility. By declaring to be gradual, it underplays its intention to make a sizable policy change, so as not to spook the market; however, if investors understand the Fed's purpose, the gradualist strategy delivers the signal that the overall desired policy change is larger than the one just made, and markets rationally react accordingly. Without taking a stance on the desirability of the gradualist approach, our paper can be seen as an empirical investigation of the findings of Woodford (2003) and Stein and Sunderam (2018).

Our paper is also related to the (scant) literature investigating the nonlinear effects of US monetary policy. Tenreyro and Thwaites (2016) show the different effects of monetary policy shocks according to the state of the business cycle (i.e., recession vs. expansion), while Barnichon and Matthes (2018) differentiate between positive and negative interest rate shocks. In a similar vein, Angrist et al. (2018) develop a semi-parametric approach to show that a monetary tightening has clear effects on economic activity, while results are less clear-cut regarding monetary accomodations. In our paper we study a different possible source of non-linearity, i.e. the potential presence of signals regarding the desired level of the target interest rate, which we proxy by the degree of inertia in monetary policy. After documenting the time variation of such inertial character of monetary policy, we show how monetary shocks differ across different inertia regimes and how they relate to the standard linear baseline.

More broadly, our paper relates to the empirical literature on monetary policy shocks, in particular to those works which developed and employed the high-frequency identification of monetary policy shocks. This approach, pioneered by Kuttner (2001) and Gurkaynak et al. (2005) and then revitalized by Gertler and Karadi (2015), focuses on movements in bond prices in a narrow window around scheduled Federal Open Market Committee (FOMC) meetings in order to recover monetary policy shocks. The literature has highlighted how such monetary shock, identified using federal fund rate futures and eurodollar futures, might embed not only surprises in the federal funds rate but also changes in the anticipated path of future interest rates, implicitly referring to the forward guidance aspect of monetary policy conduct. In our paper we stress how a different source of signaling about future interest rates other than forward guidance, i.e. the degree of inertia, might impact the transmission of monetary policy by inducing stronger reactions to monetary policy surprises. In terms of the methodology employed to uncover the non-linear effects of shocks we follow the approach proposed by Auerbach and Gorodnichenko (2016) and Ramey and Zubairy (2018) to study the non-linearities in fiscal policy, which introduce a dummy-based state-dependency in an otherwise standard local projection methodology developed by Jorda (2005), as we clarify later. Local projections in monetary policy have been employed, among others, by Ramey (2016), Nakamura and Steinsson (2018) and Stock and Watson (2018), who highlight some of the limitations of the high-frequency approach in identifying monetary shocks and clarify technical aspects related to the computation of impulse response functions.

The remainder of the paper is organized as follows. Section 2 provides both anecdotal and empirical evidence regarding the time-varying degree of monetary policy inertia. Section 3 describes the econometric methodology employed, the identification approach and the data. Section 4 reports the results obtained, and Section 5 concludes.

2 Time-varying perception of monetary policy gradualism

The gradualist approach to monetary policy has been used by the Fed at least since the chairmanship of Alan Greenspan. Gradualism involves step-by-step interest rate changes, as well as communication that explicitly points to the gradual attitude of the monetary authority. A more or less gradual policy approach, as well as stronger or weaker emphasis of gradualism in communication depend on many factors. According to the literature, gradualism can be optimal when there is high uncertainty about the impact of monetary policy (*Brainard conservatism principle*, Brainard, 1967); moreover, it can be a tool to shape expectations about future policy with the aim of controlling long-term rates and avoid market instability (Woodford, 2003); finally, by reducing the likelihood of sudden policy reversals, it can improve credibility of policy decision-making.

Regarding variation over time, gradualism can simply descend from changing economic conditions motivating that policy approach. However, it is not only that: indeed, changing preferences of FOMC members as well as the changing composition of the FOMC may have caused gradualism perception to vary over time, ceteris paribus all the other factors. Bordo and Istrefi (2018) investigate policy preferences of FOMC members between 1960 and 2015. Based on narrative records from US newspapers, they find that one third of the members who have served the FOMC were considered by the media as "swingers", i.e. switching between hawkish and dovish positions. If markets perceive a swinging FOMC, then the conduct of monetary policy might also be perceived as swinging between a gradual and a more aggressive approach. According to the paper, peaks of more than 50 percent of swingers in the Committee have been reached only in the 1990s and in the first half of the 2000s, that is exactly our period of analysis.

A glance at the evolution of the Federal funds target rate can give an idea of the monetary conduct followed by the Fed in the recent history. Figure 2.1 shows the time series of the target rate over the 1982-2019 period, where the target is proxied by the center of the policy range by 2008. First, there have been periods of time in which the target rate changed frequently, and other stretches when it did not change at all. Second, changes in the target rate have been sometimes made in gradual, 25-basis points steps – as the hiking phase of 2004-2005 – but there have also been more discontinuous patterns – as in late 1994, when sizable increases alternated with meetings with no change. In 1994, after two consecutive hikes by 25 basis points, the Board decided to pursue a less-gradual policy action. In the words of the FOMC member Forrestal in May 1994 meeting:

> *Mr. Chairman, as you know, I've been a proponent of gradualism, but I believe we're at the point where we need to take more aggressive actions. I think the gradualist approach may have created some uncertainty in the market. [...] People have suggested that if we are going to do something, we ought to take strong action. So, I'm really supportive of that action.*

Also during loosening phases, generally less gradual than phases of tightening, periods of gradual and stronger actions have alternated. Indeed, the 2001-2003 loosening phase was quite unbalanced: after the repeated large cuts made in 2001, the Board turned to a more gradual approach and cut interest rates only twice in the following two years.

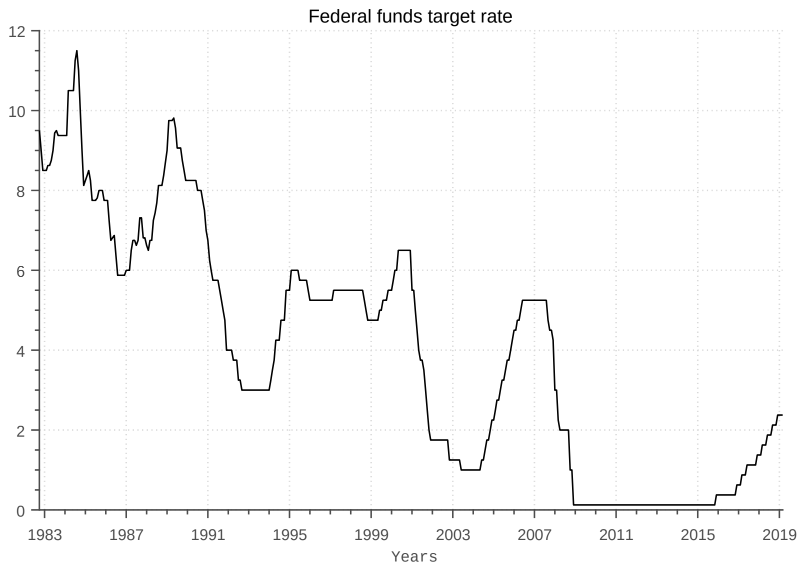

Figure 2.1: **History of the US monetary policy target rate.** Since December 2008, the target rate in the graph is the central point of the target range for the Fed funds rate.

2.1 Estimates of monetary policy inertia from Taylor rules

Several studies measure the degree of gradualism in monetary policy by estimating an *inertial Taylor rule*, where the optimal level of the federal funds rate is modeled as a weighted average of a target rate – a function of inflation and the output gap – and the lagged value of the funds rate itself. In this specification, the coefficient of the lagged funds rate captures the degree of inertia in policy. Estimates of the inertial Taylor rule made in the literature reveal a high degree of inertia in US monetary policy (0.85 in quarterly data,) which significantly increased in the 1990s and in the 2000s (Hamilton et al., 2011; Campbell et al., 2015). Other studies, however, question the importance of the inertia component by claiming that what appears to be gradual behavior is in fact the response to persistent shocks (Rudebusch, 2006).

The two opposite views on the presence of inertia in the Fed's decision-making can in part be reconciled by the fact that the inertial behavior has been time-varying. In order to evaluate the inertial content of monetary policy decisions over time, we compare the predictions made from a standard Taylor rule with those made using an inertial rule, both augmented with persistent shocks. Since Taylor (1993), the monetary policy reaction function has been characterized as a function of output gap and inflation. The modern version of the Taylor rule is based not on contemporaneous fundamentals but on expectations in real time (Orphanides, 2003) and incorporates expected output growth on top of expectations on the ouput gap (Ireland, 2004). We use the notation of Coibion and Gorodnichenko (2012) and define the Taylor rule as

$$i_t^{\star} = c + \phi_{\pi} E_{t-}(\pi_{t+h}) + \phi_{dy} E_{t-}(dy_{t+h}) + \phi_x E_{t-}(x_{t+h}) \tag{2.1}$$

where E_{t-} are expectations on macro variables at horizon h formed before the choice of the target rate, π is inflation, dy is the growth rate of output and x is output gap. The actual policy rate from a standard Taylor rule is

$$i_t = i_t^{\star} + u_t \qquad u_t \sim N(0, \sigma) \tag{2.2}$$

where u is the monetary policy shock. A modified version which incorporates persistent shocks can be written as

$$i_t = i_t^{\star} + u_t \qquad \text{where} \quad u_t = \psi u_{t-1} + \epsilon_t \qquad \epsilon_t \sim N(0, \sigma) \tag{2.3}$$

where ψ is the autoregressive component of the shock. On the other hand, the actual policy rate based on an inertial Taylor rule with same shock structure is

$$i_t = (1-\rho) i_t^{\star} + \rho i_{t-1} + u_t \qquad \text{where} \quad u_t = \psi u_{t-1} + \epsilon_t \qquad \epsilon_t \sim N(0, \sigma) \tag{2.4}$$

where ρ is the autoregressive (inertial) component of the actual policy rate. Using data from Coibion and Gorodnichenko (2012), we estimate Equations 2.2, 2.3 and 2.4 in our 1990-2006 sample.[2] Table 1 reports the results of the three estimates. Including persistent

[2]From Coibion and Gorodnichenko (2012), we use Greenbook forecasts of inflation, output growth and output gap made on months in which the FOMC meetings took place. Our estimates are made only on those months.

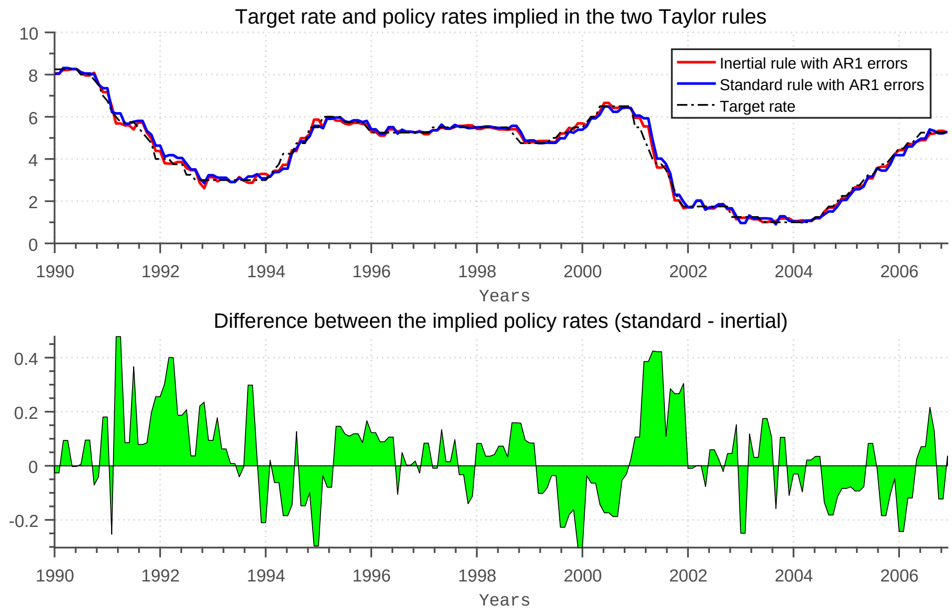

Figure 2.2: **Taylor rule-implied inertia.** Top panel: target Federal funds rate and policy rates implied from a standard and an inertial Taylor rules, both augmented with AR1 shocks. Bottom panel: difference between the policy rates implied by the two rules.

shocks in the standard Taylor specification improves model performance (Regressions (1) and (2)). However, when the inertial component of the policy rate is also included, the coefficient of the AR(1) component of the shock drops from 0.99 to 0.19, and becomes significant only at the 5 percent level; the inertial parameter is instead significant at the 1 percent level.

Given that Equation 2.3 is nested in 2.4, we can quantify the degree of gradualism embedded in monetary policy decisions at each point in time by taking the difference of the implied policy rates from the two rules. The top panel of Figure 2.2 shows the target rate (dotted line) and the implied policy rates according to the two rules (solid lines). Both specifications track closely the observed target rate. The (significant) difference between the two is plotted in the bottom panel of the same figure, suggesting two insights. First, not all cycles are alike: during some of them the difference between the two implied rates has been large, while in other cases small, suggesting that the reaction of the Fed has been gradual in some periods and timely and abrupt in others. Second, even within one tightening or loosening phase, the inertial component of the decision varies significantly. In general, the adoption of a gradual approach has not been systematic in the recent history.

Three versions of the Taylor rule			
Parameter	(1)	(2)	(3)
c	1.38^{***}	5.39^{***}	-0.14
	(0.48)	(1.26)	(0.10)
ϕ_π	1.64^{***}	0.17^{***}	0.24^{***}
	(0.16)	(0.06)	(0.04)
ϕ_{dy}	0.66^{***}	0.34^{***}	0.09^{***}
	(0.06)	(0.08)	(0.02)
ϕ_x	-0.13^{*}	-0.02	0.07^{***}
	(0.08)	(0.02)	(0.02)
ψ		0.99^{***}	0.19^{**}
		(0.01)	(0.09)
ρ			0.88^{***}
			(0.03)
Observations	136	136	136
Adjusted R-square	0.863	0.983	0.989

Table 1: **Estimates of the Taylor rule.** (1): standard Taylor rule (Equation 2.2). (2): Taylor rule augmented with AR(1) errors (Equation 2.3). (3): Taylor rule augmented with AR(1) errors and inertia coefficient (Equation 2.4). Regression (1) is estimated by least squares, Regressions (2) and (3) by maximum likelihood. HAC standard errors.

3 Empirical approach

In this section we describe our empirical methodology to estimate the transmission of monetary policy in times of gradual or less gradual policy. In a linear projection framework, we consider gradualism as our state variable and use it to measure the effect on monetary shocks in high-low gradualism states.

3.1 Local Projections with instrumental variables (LP-IV)

Local projections (LP henceforth), first introduced in Jorda (2005), are becoming an increasingly popular estimation tool to compute impulse response functions (IRFs) as opposed to more standard methods which retrieved them from estimated structural vector autoregressive models (VARs). A wide range of estimation procedures can in principle be applied to estimate LPs, and our approach hinges on a standard instrumental variable (IV) strategy. Local projections are flexible enough for both linear and nonlinear specifications. In this paper, we employ both linear and state-dependent local projections to compute our impulse responses to monetary policy shocks in states of high and low perceived gradualism.

Linear LP. Generally, the kind of linear LP we are interested in can be written as

$$y_{t+s} = \alpha_s + \beta_s \epsilon_t + \boldsymbol{\psi}_s(L)\mathbf{X}_{t-1} + u_{t+s} \quad s = 0, 1, 2, \ldots, H, \tag{3.1}$$

where $\mathbf{y}$ is the target variable, ϵ is the exogenous shock (here, exogenous variations in the 1-year US Treasury yield instrumented with high-frequency monetary policy surprises), and $\mathbf{X}_t$ is a vector of control variables. Estimation is performed separately for each time horizon s and for each dependent variable with a two-stage least squares procedure. In the first stage, the 1-year yield is regressed on the instrument, i.e. surprises on market prices – aggregated at the monthly frequency – and some control variables; then, fitted values of the 1-year yield are used as exogenous shocks in the second stage, in which the target variables at each horizon are regressed onto the shock series, their own lags and other controls. Impulse responses are defined by the sequence $\{\beta_s\}_{s=0}^{H}$, and inference is performed with Newey-West standard errors.

State-Dependent LP. The local projection technique allows to compute impulse responses that include non-linear effects of shocks. For our purposes, we investigate the extent to which monetary policy is transmitted under two (mutually exclusive) different regimes, defining them with an indicator variable. Specifically, our two-regimes, state-dependent local projections are defined as follows

$$\begin{aligned} y_{t+s} = & I_t \left[\alpha_{A,s} + \beta_{A,s} i_t + \boldsymbol{\psi}_{A,s}(L)\mathbf{X}_{t-1}\right] + \\ & (1 - I_t) \left[\alpha_{B,s} + \beta_{B,s} i_t + \boldsymbol{\psi}_{B,s}(L)\mathbf{X}_{t-1}\right] + u_{t+s} \quad s = 0, 1, 2, \ldots, H. \end{aligned} \tag{3.2}$$

where I is the indicator variable which splits the sample according to state A and state B. The two sets of estimated parameters have A and B subscripts. As in the linear case, we adopt the two-stage least squares procedure, in which each of the two regimes is estimated separately on its appropriate set of observations.

Dummy-based state-dependency has been adopted by Ramey and Zubairy (2018), among others. Other authors - e.g. Tenreyro and Thwaites (2016) - use smooth transition local projections, which allow parameters to smoothly switch between the regimes, instead of letting them change abruptly around a threshold. While a smooth transition could in principle be preferable, its estimation relies on two key curvature and location parameters, whose calibration turns out to be important in shaping the final set of obtained IRFs.[3] We therefore decided to stick with the easier to interpret (and more robust) discrete indicator variable, which yields a cleaner interpretation of the coefficients as exact average causal effects within a given state. One important prerequisite of state-dependent estimations is that the state variable must be exogenous with respect to the shock, at least at the time in which the latter occurs.

In our framework, we introduce the state as a contemporaneous instead of lagged variable. We do that because our mechanism (i.e., the reinforcing effect of gradualism on monetary policy transmission) would have otherwise been imputed to the wrong period (time $t-1$ instead of time t), i.e. when no "gradualism signal" was present. Nonetheless,

[3] In principle, those parameters could be estimated, but in order to do so reliably the researcher would need a lot of data around the transition of the state variable, something that is virtually never the case in macroeconomic applications. Terasvirta (1994) discusses those estimation issues in detail.

we believe that the endogeneity with the response variable is not an issue in our settings for at least two reasons. First, Fed's choices (and in particular the decision of being gradual) are based on real macro variables that are available with a lag, so the determinants of gradualism are also obviously lagged in a monthly framework. This is even more true in our settings, because our baseline indicator depends not only on the current policy rate change but also on the two most recent ones. Moreover, the Fed tracks hundreds of economic indicators, and in no way it takes decisions exclusively based on the most recent data-points of one of them.

3.2 High-frequency identified shocks

As it is common in the empirical monetary policy literature, we use asset price variations around the time in which FOMC statements are released to proxy market surprises to policy decisions. The literature is pioneered by Kuttner (2001) and Gürkaynak et al. (2005), whereas Gertler and Karadi (2015) apply their methodology to a broader set of market variables such as Federal funds futures and Eurodollar futures at multiple maturities. In order to capture market reactions specifically related to FOMC statements, Gürkaynak et al. (2005) define high-frequency surprise as the difference between futures prices 20 minutes after and 10 minutes before FOMC announcements.[4]

Thirty-minute surprises have to be converted into monthly average surprises to instrument interest rate variations at the lower (monthly) frequency. This computation is complicated by the fact that meetings occur only in some months and, in those months, they can be held at beginning or at the end of the month: in the latter case, the surprise is expected to have a smaller influence on average rates. To overcome this problem, Gertler and Karadi (2015) construct cumulated daily surprises using 31-day windows and average them in each calendar month. While this method generate autocorrelated

[4]For a comprehensive explanation of the technicalities involved in the Federal Funds Futures market, see Hamilton (2008).

monthly surprises (as highlighted by Ramey, 2016), they can still be used as instrument in a monthly framework once a sufficient number of instrument lags are added as controls in the first-stage regression (Stock and Watson, 2018).

This is what we do in our analysis: we use Gertler and Karadi (2015) surprises and control for their lags in estimation.[5] In particular, we use surprises which perform best in instrumenting one-year yields, i.e. 3-month Federal funds futures. The price of Federal fund futures embeds expectations about future values of the Federal funds target rate and a risk premium, and contracts settlement is based on the average effective Federal Funds Rate realized over the expiration month. On top of their nice econometric properties, 3-month futures are particularly suitable to construct monetary shocks in periods of high and low gradualism. Indeed, variations in the level of expected Fed funds rates reflect both current and future changes of the policy target within the three-month horizon. We therefore expect these two components of the monetary surprise to have different relevance depending on the perception of past and actual monetary policy conduct.

3.3 Data

In this section we describe the data employed throughout our empirical analysis. We use monthly data, with a sample ranging from 1990:1 until 2006:12.[6] Regarding the domestic variables considered in the empirical section, we include the following: industrial production, CPI inflation, the mortgage rate spread (vis-a-vis the 10-year government bond yield), the real effective exchange rate of the US dollar, the 3-month commercial paper spread and the excess bond premium of Gilchrist and Zakrajsek (2012). Regarding the interest rates we include the one-, two- and ten-year US government bond yields. The

[5] As an alternative surprise series, one could use that of Miranda-Agrippino and Ricco (2017) who construct monthly average surprises by using unweighted daily surprises in meeting months, and 0 otherwise. While not generating autocorrelation, surprises occurred at the beginning and at the end of each month are in this way assumed to be equally informative for the average variation of short-term interest rates in a given month.

[6] We do not consider the period after the great financial crisis as monetary policy was constrained by the zero lower bound.

monetary policy surprises which proxy our shocks have already been described in Section 3.2. All variables except interest rates have been transformed into natural logarithms.

4 Results

4.1 The linear case

In this section we compute the impulse response functions (IRFs) following a tightening US monetary policy shock of 25 basis points. The IRFs are computed in the linear case, i.e. using equation 3.1. Control variables in the first and second stage of the LP-IV procedure are the following: four lags of the dependent variable, of the instrumented variable (the 1-year yield), of the surprise itself and of the excess bond premium; we also include lags of the long rate as it is significant in both stages.[7] Responses are displayed up to 36 months after the shock, along with 90% and 68% confidence bands. Figure 4.1 reports the results for government bond yields. The 1-, 2- and 10-year yield all increase after the shock. The reaction is comparable in terms of magnitude across maturities, where the 10-y yield increases slightly less than shorter rates. Figure 4.2 shows the results for interest rate spreads and real variables. Concerning the former, the excess bond premium increases on impact and becomes not significant later on: this behavior is very similar to that found by Plagborg-Møller (2016) in a larger sample; the commercial paper spread shows a similar dynamics, also reinforcing the transmission of the monetary policy, while the response of the mortgage spread is not significant. Regarding macro variables, industrial production falls, as well as inflation, although at a subdued pace. The real exchange rate appreciates, although the response is not abrupt and becomes significant only after ten months.[8] Such puzzling behavior, usually defined as *delayed overshooting puzzle*, has been highlighted by the literature studying the effects of monetary policy on the exchange rate. In a recent

[7]For industrial production, we replace the long rate with inflation in the set of controls, as in Stock and Watson (2018).

[8]The same applies to the nominal exchange rate, not reported.

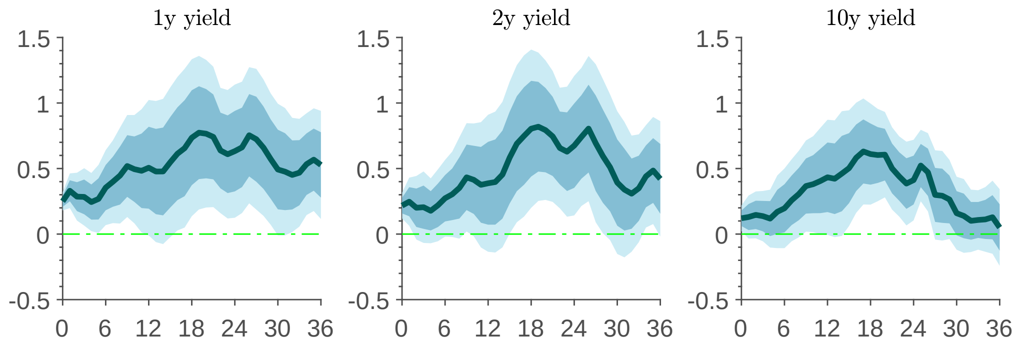

Figure 4.1: **The effects of US monetary shocks in a linear world – bond yields.** Impulse responses of US variables following a 25 basis points monetary policy shock. Heteroscedasticy and autocorrelation robust standard errors with *h+1* lags, where h is the horizon of the local projection at time t. 90% (light blue) and 68% (dark blue) confidence bands.

paper, Kim et al. (2017) observe that the impact response of exchange rates to monetary shocks is significant (i.e., the puzzle disappears) if one excludes the period of the Paul Volcker's chairmanship of the Federal Reserve from the estimation sample. Using a different estimation framework and identification strategy, we instead document that the real exchange rate responds to US monetary shocks with delay even in the post-Volcker sample.

More generally, we observe that the response of interest rates and exchange rates are either hump-shaped or they occur with a delay. This is in line with what found by other studies employing the high frequency approach in combination with the LP-IV method, such as Ramey (2016). Industrial production displays a well-behaved response, consistent with economic theory and with the empirical findings by Stock and Watson (2018) and in contrast with Ramey (2016) documenting a puzzling behavior of output some periods after the shock.[9] All in all, our linear effects of monetary shocks are consistent with theoretical predictions and with previous empirical literature. This allows us to turn to the central part of the paper, i.e. the investigation of the non-linear transmission of monetary policy in times of high and low gradualism.

[9]The puzzling behavior in Ramey (2016) also depend on control variables included in local projections; in this respect, we follow Stock and Watson (2018) showing that, once controlling for enough lags of the surprise, the identified monetary shock can be safely used and yields reliable impulse responses.

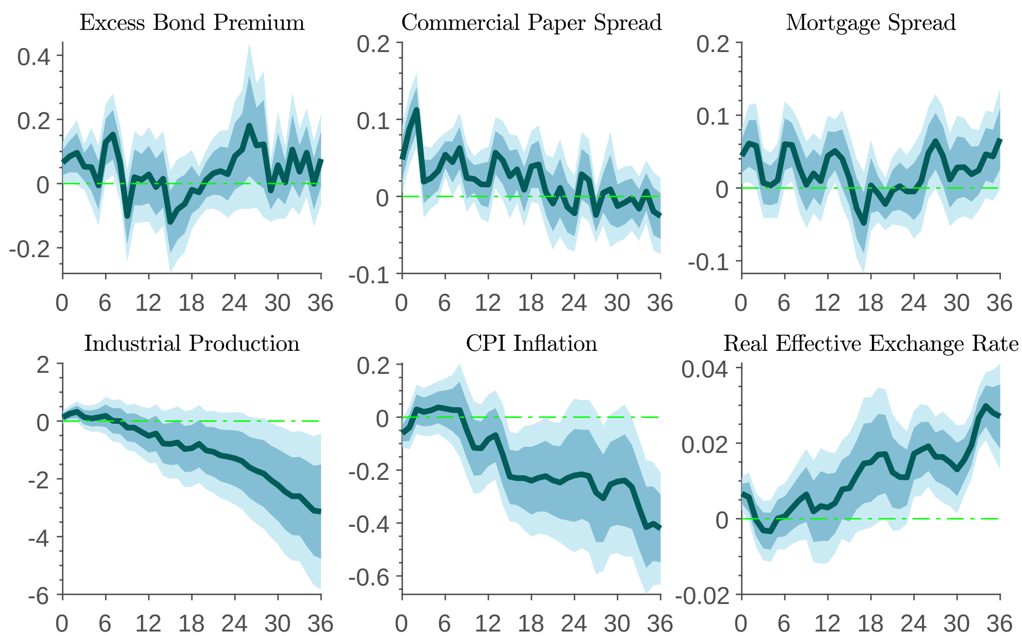

Figure 4.2: **The effects of US monetary shocks in a linear world – interest rate spreads and macro variables.** Impulse responses of US variables following a 25 basis points monetary policy shock. Heteroscedasticy and autocorrelation robust standard errors with *h+1* lags, where *h* is the horizon of the local projection at time *t*. 90% (light blue) and 68% (dark blue) confidence bands.

4.2 Baseline indicator of high and low gradualism

As discussed in the Introduction, the time-varying perception of investors towards gradualism can shape the response of financial markets to monetary shocks. In order to investigate related state-dependence in the transmission of monetary policy, one needs to rely on some metrics to isolate periods of time in which monetary policy was perceived as gradual from times in which it was perceived as less gradual. While the difference between the optimal policy rates implied by the two augmented Taylor rules in Figure 2.2 is an indicator of policy inertia, it cannot be used to proxy the *perceived* degree of gradualism because (1) it is based on ex-post information embedded in Taylor rule parameters and (2) it incorporates the Fed's private information in the form of the Greenbook forecasts.

Gradualism has never been defined formally, so there is no standard way to measure it (and its perception) in real time. We propose two different indicators of the perception of monetary policy gradualism, based respectively on historical target rate moves and on narrative readings of newspaper articles, and use them to identify states of gradual and less gradual policy (high and low gradualism, henceforth). In order to construct a real time, private agent-based indicator, we here rely on the idea of gradualism as it emerged in the monetary policy debate of the early 1990s . The explicit adoption of gradualism in the United States dates back to, at least, the Greenspan era. In the FOMC meeting of 22 March 1994, Greenspan expressed his idea on how a gradual approach should work in influencing expectations on futures policy rates. Below is an extract from the transcripts of the meeting, also reported by Coibion and Gorodnichenko (2012) as an example of Greenspan's thinking on this topic:

> *My own view is that eventually we have to be at 4 to 4 1/2 percent. The question is not whether but when. If we are to move 50 basis points, I think we would create far more instability than we realize, largely because a half-point is not enough to remove the question of where we are ultimately going. I think there is a certain advantage in doing 25 basis points because the markets, having seen two moves in a row of 25 basis points at a meeting, will tend almost surely to expect that the next move will be at the next meeting – or at least I think the probability of that occurring is probably higher than 50/50. If that is the case and the markets perceive that – and they perceive we are going to 4 percent by midyear, moving only at meetings – then we have effectively removed the Damocles Sword because our action becomes predictable with respect to timing as well as with respect to dimension.*

The concept of gradualism expressed by Greenspan can be summarized as follows: the Federal Reserve has private information on the appropriate level of the target rate and, by moving gradually, signals its intention to modify the monetary stance also in the following meetings. Investors observing multiple hikes in a row understand that, except in extreme cases, those increases are not due to repeated variations in the Fed's view: therefore, they adjust their expectations on future monetary policy moves accordingly (i.e., in this example, attach a higher probability to another hike at the next meeting).

The idea that the perception of gradualism is a learning process is suitable to define states of high and low gradualism in the conduct of monetary policy. In the high gradualism state, investors perceive that monetary policy is moving more gradually than predicted by fundamentals, and embed it in their reaction function; conversely, in the low gradualism state, they do not perceive any signal and intepret the size of current monetary actions as only driven by the Fed's forecasts on fundamentals.[10] We denote as $\Delta i_t = i_t - i_{t-1}$ the first difference in the time series of the observed target rates at time t. Then, we define an indicator of gradualism (I_1) as a dummy variable which takes the value 1 if the changes in the policy rate in the current and the last two meetings have been of 25 basis points (i.e., multiple consecutive 25 bps hikes or cuts), and 0 otherwise, i.e.

$$I_{1,t} = \begin{cases} 1 & \text{if} \quad \Delta i_t = \Delta i_{t-1} = \Delta i_{t-2} = 25 \text{ bps} \quad \text{or} \quad \Delta i_t = \Delta i_{t-1} = \Delta i_{t-2} = -25 \text{ bps} \\ 0 & \text{otherwise} \end{cases}$$

The top panel of Figure 4.3 displays the historical values of the Federal funds target rate, highlighting with white shaded areas the states of high perceived gradualism identified with the aforementioned procedure. According to that, signals of gradualism were persistently provided during the loosening phase of the early 90s and 2001, as well as during the tightening phase of 2004-2006; also, there were shorter periods of high gradualism between them. In total, states of high gradualism cover 20 percent of total observations

[10]Obviously, in this definition of gradualism, periods of high gradualism encompass not only the first moves of the Fed (which should embed the strongest signals) but also the following moves if policy continues to be step-by-step. While the signal on gradualism in the following moves should be weaker than after the first few moves, it is nonetheless material, because each target change in the same direction reinforces the idea that the long-term desired target rate is still far away.

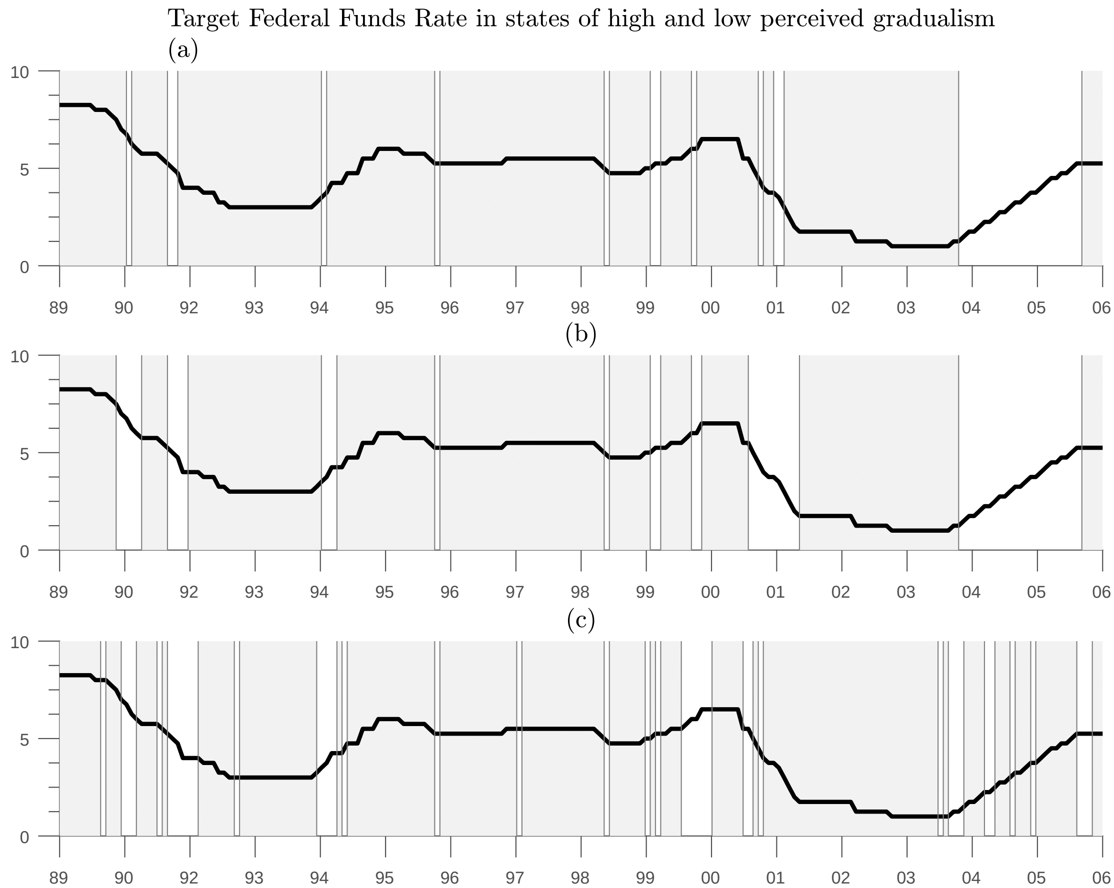

Figure 4.3: **States of high and low perceived gradualism**. Repeated 25 bps target rate moves (top panel), repeated target rate moves of the same sign (medium panel), narrative approach (bottom panel). White (grey) shaded areas indicate periods of high (low) perceived gradualism.

in our sample.

Other indicator: robustness

The concept of gradualism expressed by Greenspan in March 1994 was referred to 25 basis point moves only, but it can also be extended to repeated moves in the same direction: i.e., repeated increases or repeated decreases of the target rate, no matter the size of each change. As a robustness check, we propose another version of this indicator (named I_a for *robustness*) in which gradualism signals are delivered in all of these cases. According to this looser specification, high gradualism should be perceived in a slightly larger part

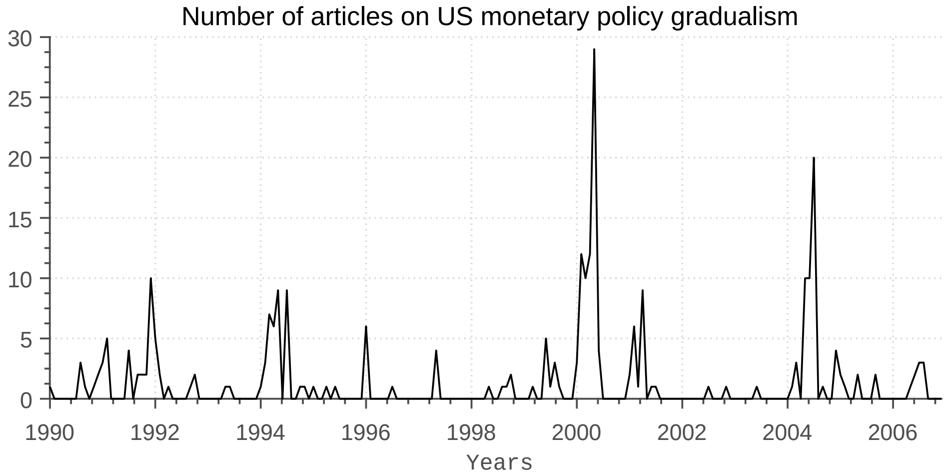

Figure 4.4: **Count of newspaper articles related to Fed's gradualism.**.

of the sample (see Figure 4.3, medium panel). The indicator variable is defined as

$$I_{a,t} = \begin{cases} 1 & \text{if} \quad \Delta i_t = \Delta i_{t-1} = \Delta i_{t-2} > 0 \quad \text{or} \quad \Delta i_t = \Delta i_{t-1} = \Delta i_{t-2} < 0 \\ 0 & \text{otherwise} \end{cases}$$

4.3 Narrative indicator

Greenspan's concept of gradualism is based on learning from repeated policy moves. However, the gradualist approach is also sometimes emphasized explicitly in monetary policy statements and speeches, and related wording can give signals to the market even before changes in the target rate take place. As a robustness check, we also propose a narrative indicator of gradualism based on the presence or absence of a debate on the Fed's gradualism in newspapers. This alternative indicator is based on the idea that news articles can shape significantly market perception of gradualism: if the Fed declares its intention of being gradual or simply debates on the possibility of adopting a more gradual approach, this is timely reported by newspapers and, through them, can give a signal to the markets. It is important to point out that this can be seen as an indirect way to capture the gradualism signal, that is something related to policy actions, not to communication;

for this reason, the signal on gradualism extracted from newspaper articles is more noisy than that obtained in the previous ways. We therefore consider this alternative specification as a further robustness test of our claim.

To construct our indicator, we use the Dow Jones Factiva tool to search all newspaper articles since January 1990 which discussed the Fed's gradualist approach. Following Caldara and Iacoviello (2018), we restrict the number of newspapers to 11, all of them covered by Factiva since the beginning of the 1990s.[11] We then search a set of words/couples/triples related to gradualism and select articles in which they appear in conjunction with the Federal Reserve (or the FOMC). To avoid articles in which gradualism is not related to the Fed (even if the Fed is mentioned), we only select those in which the set of terms related to the Fed are present in the same *paragraph* as terms on gradualism.[12] Figure 4.4 displays the count of articles on Fed's gradualism on a monthly basis, between January 1990 to December 2006. The figure confirms that the debate on gradualism has been larger in the 2000s, in line with Hamilton et al. (2011), but is also substantial during the 90s. We construct our narrative-based indicator of high and low gradualism as follows. We assign value 1 to months in which there is debate on gradualism (more than 1 article in the selected newspapers), and 0 otherwise:[13]

$$I_{2,t} = \begin{cases} 1 & \text{if} \quad \text{n. of articles on Fed's gradualism} > 1 \\ 0 & \text{otherwise} \end{cases}$$

The I_2 indicator is shown using shaded areas in the bottom panel of Figure 4.3. The num-

[11] The newspapers are Boston Globe, Chicago Tribune, The Daily Telegraph, Financial Times, The Globe and Mail, The Guardian, Los Angeles Times, The New York Times, The Times, The Wall Street Journal, The Washington Post.

[12] The used search keyword is
`(Federal Reserve or FOMC or (Fed not (fed up or fed into or fed funds))) same (gradualism or policy inertia or gradualist or gradual approach or incremental approach or interest rate smoothing or inertial policy or gradual behavior or incrementalist or incrementalism or gradual behaviour or incremental behaviour or incremental behavior)`

[13] One is the average number of articles on gradualism in our sample.

ber of periods of high perceived gradualism are in line with those found with I_1 (here, 21 percent of the sample). While coming from two inherently different identification strategies, the high-gradualism periods overlap, at least on a yearly basis, with those obtained in the previous ways. In both procedures, signals on gradualism are found to be delivered, for example, in 1991, 1994 and 2004. Note that high-gradualism states identified by the I_2 indicator are more spread throughout the sample than those found with the previous techniques.

4.4 Properties of our state variables

Before presenting the estimation results, we study how our baseline and narrative state variables correlate with each other. We do this to show whether they both capture the same phenomenon, i.e. gradualism in monetary policy, even if they are constructed from conceptually different methods. Moreover, we also compute correlations with other macro variables to assess whether our state variables overlap with them; for this purpose, we focus on indicators of business cycle and monetary policy uncertainty (MPU henceforth), the main candidates to covary with our state variable. As proxies for the business cycle, we use NBER recession dates and the industrial production growth rate; concerning monetary policy uncertainty, we employ the indicators provided by Husted and Sun (2017) and Baker et al. (2016) (HRS and BBD henceforth). With respect to those variables, our aim is to investigate the relationship between periods of high gradualism and periods of recession/low growth or high monetary policy uncertainty. Provided that, according to our indicators, high gradualism states occur approximately in the 25% of the sample, we consider as low-growth states all industrial production growth rates below the 25th percentile, and high-uncertainty states as those above the 75th percentile. Table 2 shows that the two indicators of gradualism are enough correlated with each other (24%) and that correlations with the other variables is low (always below 10% in absolute value). Bootstrapped confidence intervals reveal that correlations among each other is statisti-

	I_1	I_2
I_1	100%	·
I_2	24.1%	100%
other state variables:		
IP growth	0.0%	7.0%
NBER recessions	3.8%	9.8%
MPU (HRS)	3.0%	1.4%
MPU (BBD)	-8.9%	9.8%

Table 2: Correlations between high/low gradualism states (according to our I_1 and I_2 indicators) and dummies for NBER recession/expansion, low/high IP growth and high/low monetary policy uncertainty.

cally significant, while that with other state variables never is. The latter estimates are also robust to different specifications of low-growth and high-uncertainty states, such as below-median growth and above-median uncertainty. We take this as evidence that our indicators do not overlap with cycle/uncertainty-related state variables.

Another possible concern is whether there exist significant differences in the distribution of our identified shocks across the two states. Reassuringly, this is not the case: a formal two-sided t-test of equality of the mean of the shock does not reject the null hypothesis that they are equal in the two sub-samples at any reasonable significance level (p-value equal to 0.78).[14]

4.5 Impulse response functions

Using the state variables I_1, I_a and I_2 defined above, we compute state-dependent impulse responses to a 25 basis point monetary policy shock using the LP-IV framework. Control variables are the same used in the linear framework, although the number of lags is reduced because of the lower number of observations in sub-samples. Impulse responses are reported in Figures 4.5 to 4.10. Blue lines and shades display responses in the high

[14] Confidence bands of correlation coefficients and histograms of the shock distribution in the two states are available upon request.

gradualism state, while orange lines and shades those in the low gradualism state. Before discussing the effect of the shocks in the two states, we need to assess the validity of the employed monetary policy instrument in our states. For this purpose, we run F-tests on the first stage regressions for each of the three specifications. Results of the tests are reported in Table 3. Values of the F statistics are always greater than 10, the threshold value recommended by Stock et al. (2002), in both the high and low states.[15] Therefore, the FF4 surprise cannot be considered a weak instrument in all the sub-samples considered.

F-statistic	**High state**	**Low state**
Repeated 25 bps moves (I_1)	23.491	19.403
Repeated hikes and cuts (I_a)	14.27	18.93
Narrative approach (I_2)	32.62	13.38

Table 3: F statistics of the first stage regressions in the high and low states.

Figure 4.5 reports the state-dependent responses of interest rates for the gradualism state I_1, that we consider as the baseline. The effect of monetary shocks in the high and low states are significantly different for yields at all maturities. In the low gradualism state, bond yields show the typical evolution that follows a standard monetary policy shock in a local projection framework, i.e. a positive impact effect that persists for several months before slowly reverting back. The response in the high state is instead different: while the impact responses are similar in magnitude to those in the low state, they increase steadily in the following 18 months after the shock, exhibiting hump-shaped IRFs. Such behavior resembles the reaction to a news shock more than a surprise shock. This evidence squares well with our interpretation of high gradualism as a state in which the private sector receives a signal regarding the *future* evolution of monetary policy, i.e. a

[15]By including lagged values of the instrument, of the 1-year yield and of all the other control variables in the first stage, residuals of the regressions are not serially correlated, so we do not need to use the adjusted version of the F-statistic recommended by Montiel Olea and Pflueger (2013) in case of serial correlation.

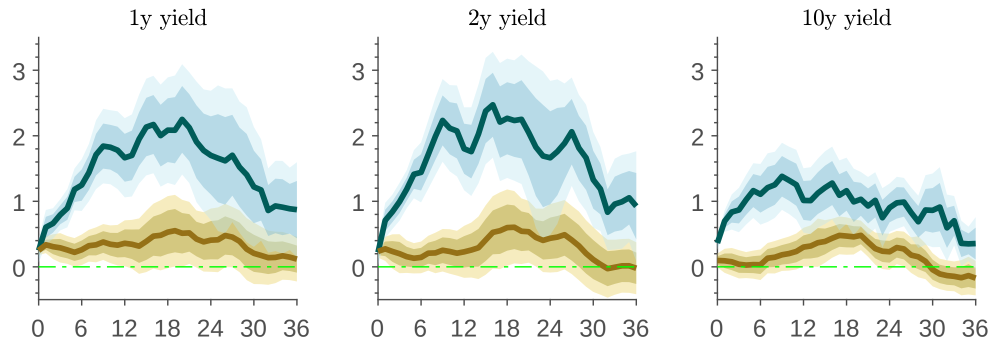

Figure 4.5: **IRFs of interest rates, baseline I_1 gradualism states.** Impulse responses of US variables following a 25 basis points monetary policy shock. The states of high gradualism are based on repeated 25 bps target rate moves. Blue (orange) lines indicate states of high (low) perceived gradualism. Heteroscedasticy and autocorrelation robust standard errors with h+1 lags, where h is the horizon of the local projection at time t. 90% (light shades) and 68% (dark shades) confidence bands.

news on future policy rates on top of the surprise on current ones. This interpretation is confirmed by the response of the 10-year yield, which has a stronger impact reaction in the high than in the low state as it incorporates information regarding future short-term rates; after that, the IRF remains significantly above the one obtained in the low state throughout the entire estimation horizon.

The different evolution of interest rates in the two states is the main result of the paper. It implies that different degrees of gradualism in the conduct of monetary policy have substantial implications for its transmission to financial markets. It is important to point out that what drives this result is not a different size of the shock in the two states – as noted in Section 4.4 – but the additional information regarding future monetary policy embedded in the high state which build up slowly in impulse responses over time. In this perspective, the *news* content in the variation of the 3-month Fed funds futures should have a prominent relevance in high states, while the *surprise* related to the current target rate should be more important in low states. Such interpretation also reconciles another finding in the literature on monetary responses obtained with high-frequency shocks, i.e. the slow and hump-shaped response of interest rates in the linear case (see Section 4.1). As the linear response is simply the weighted average of the IRFs in the two states, our investigation shows how the presence of information regarding future rates in the high

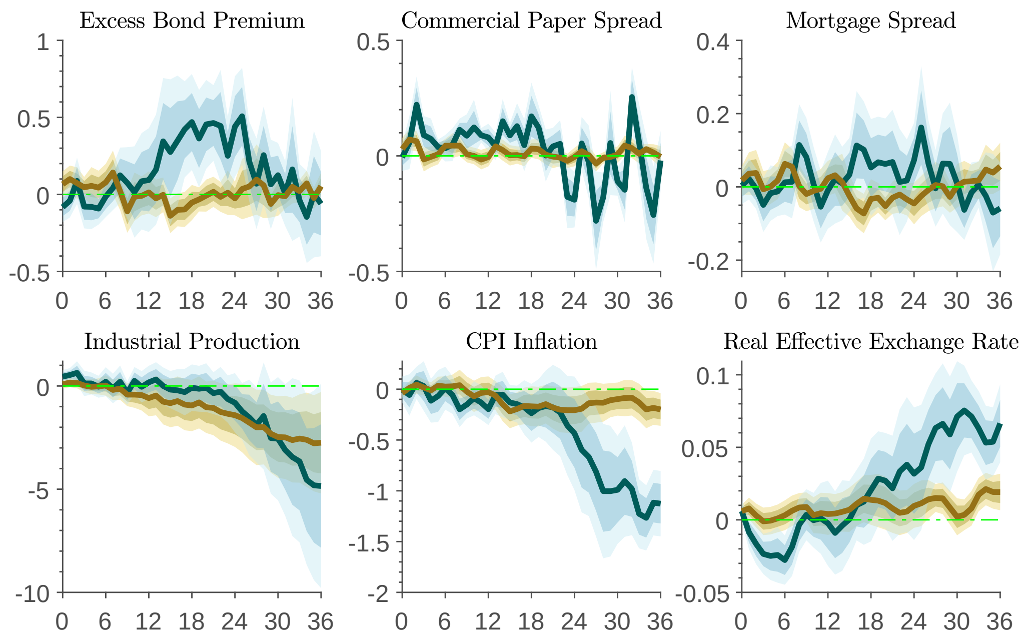

Figure 4.6: **IRFs of interest rate spreads and macro variables, baseline I_1 gradualism states.** Impulse responses of US variables following a 25 basis points monetary policy shock. The states of high gradualism are based on repeated 25 bps target rate moves. Blue (orange) lines indicate states of high (low) perceived gradualism. Heteroscedasticy and autocorrelation robust standard errors with $h+1$ lags, where h is the horizon of the local projection at time t. 90% (light shades) and 68% (dark shades) confidence bands.

gradualism state makes linear impulse responses also hump-shaped.

Figure 4.6 displays the effects on interest rate spreads and macroeconomic variables. Concerning the spreads, the different response in the two states is front-loaded in the case of the commercial paper spread, while it appears about one year after the shock for the excess bond premium and the mortgage spread (for the latter, responses are barely significant). A delayed response is also visible in the case of the other variables considered, although they are not always statistically different. After a tightening monetary shock, industrial production slowly decreases in both states, showing a similar and barely significant dynamics. Differently, inflation falls more in the high state, where the different response in the two states appears two years after the shock. The real exchange rate has a similar response (with opposite sign) than inflation, i.e. it remains mostly not significant for the first two years after the shock, then it appreciates more strongly towards the end

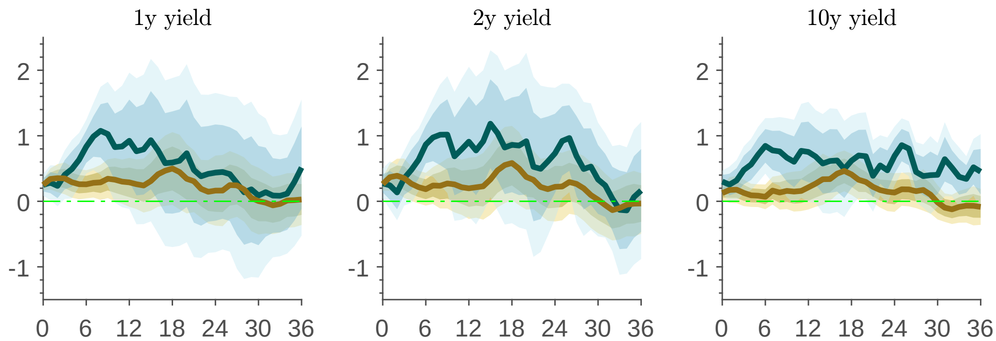

Figure 4.7: **IRFs of interest rates, robustness I_a gradualism states.** Impulse responses of US variables following a 25 basis points monetary policy shock. The states of high gradualism are based on repeated target rate moves of the same sign. Blue (orange) lines indicate states of high (low) perceived gradualism. Heteroscedasticy and autocorrelation robust standard errors with *h+1* lags, where *h* is the horizon of the local projection at time *t*. 90% (light shades) and 68% (dark shades) confidence bands.

of the estimation period in the high state.

Results of the estimates using the I_a as state variable, i.e. the extended version of the baseline indicator which consider any kind of repeated rate changes in the same direction for the high gradualism state, are reported in Figures 4.7 and 4.8. Overall, impulse responses confirm the findings obtained with the baseline state I_1. The difference in the response of interest states in the high and low state appears to be lower than that obtained with I_1. This probably reflects the fact that the perception of gradualism is higher when policy rate changes are always of the smallest size than in other cases: policy changes that are discontinuous in size might sometimes be interpreted as changes in the strategy, while sequential 25 basis points deliver a clearer signal. The effects on interest rate spreads are similar to those obtained in the baseline case. While the response of industrial production and exchange rate in the high state are not well behaved in the first months after the shock, the similar evolution of IRFs with the baseline case generally applies also to macro variables.

Figure 4.9 and 4.10 report the result obtained using the alternative gradualism state I_2, i.e. the one constructed by selecting periods in which newspaper articles mention the debate on gradualism. Even with the narrative approach, we obtain a stronger reaction

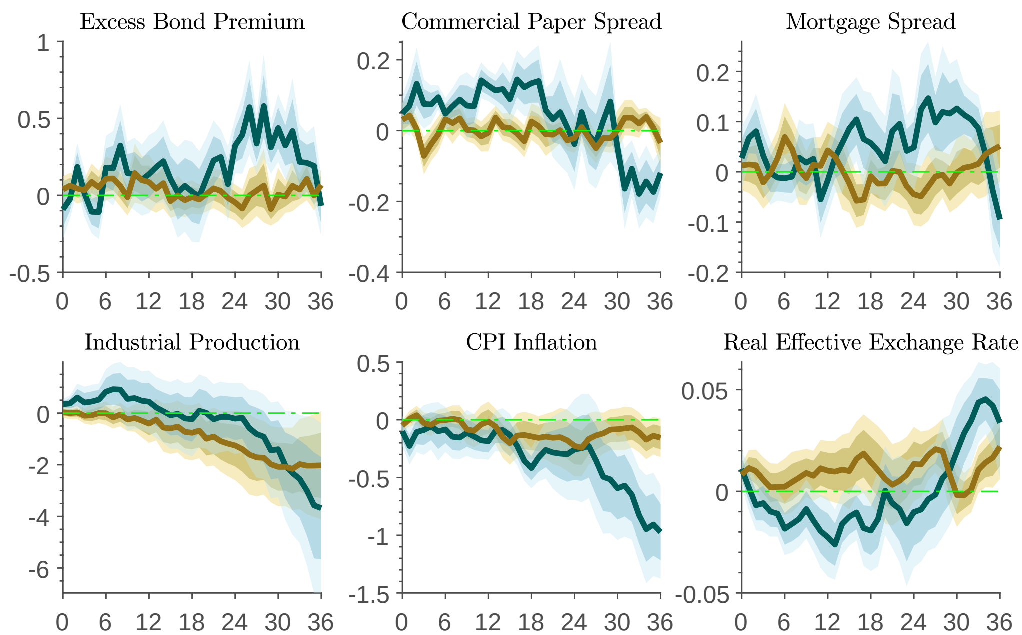

Figure 4.8: **IRFs of interest rate spreads and macro variables, robustness I_a gradualism states.** Impulse responses of US variables following a 25 basis points monetary policy shock. The states of high gradualism are based on repeated target rate moves of the same sign. Blue (orange) lines indicate states of high (low) perceived gradualism. Heteroscedasticy and autocorrelation robust standard errors with *h+1* lags, where *h* is the horizon of the local projection at time *t*. 90% (light shades) and 68% (dark shades) confidence bands.

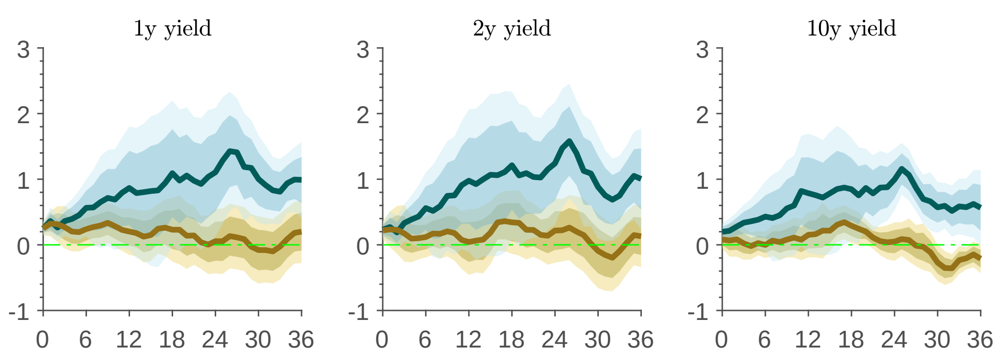

Figure 4.9: **IRFs of interest rates, alternative gradualism states (I_2).** Impulse responses following a 25 basis points monetary policy shock. The states of high gradualism are based on newspaper articles mentioning gradualism. Blue (orange) lines indicate states of high (low) perceived gradualism. Heteroscedasticy and autocorrelation robust standard errors with *h+1* lags, where *h* is the horizon of the local projection at time *t*. 90% (light shades) and 68% (dark shades) confidence bands.

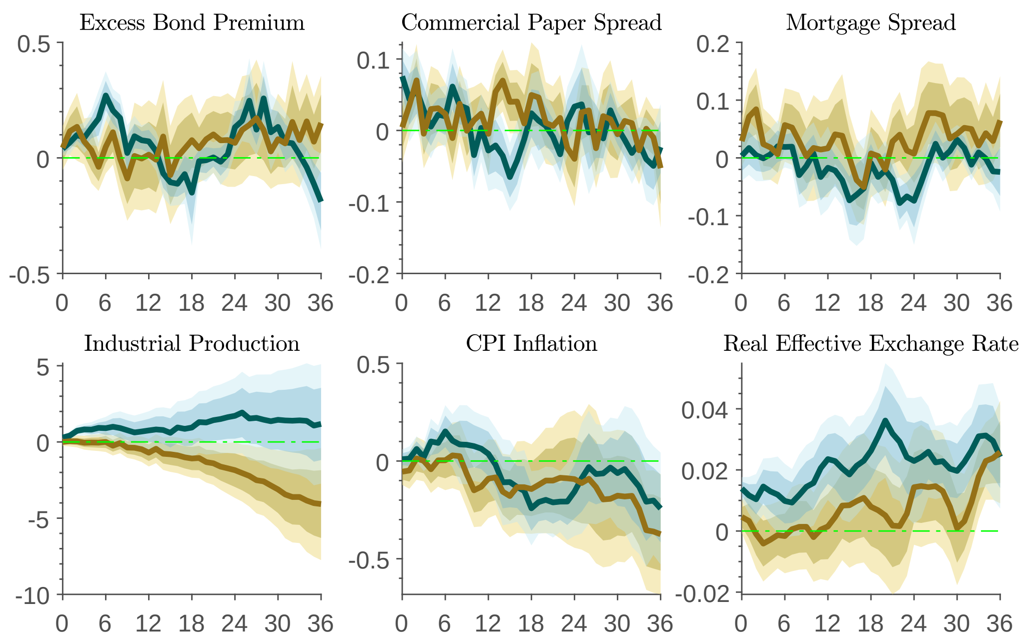

Figure 4.10: **IRFs of interest rates, alternative gradualism states (I_2).** Impulse responses following a 25 basis points monetary policy shock. The states of high gradualism are based on newspaper articles mentioning gradualism. Blue (orange) lines indicate states of high (low) perceived gradualism. Heteroscedasticy and autocorrelation robust standard errors with *h+1* lags, where *h* is the horizon of the local projection at time *t*. 90% (light shades) and 68% (dark shades) confidence bands.

of interest rates to monetary policy shocks in the high vs. low gradualism state. With respect to the previous IRFs of bond yields, we now observe a more delayed reaction, with impulse responses peaking between 2 and 3 years after the shock; regarding the magnitude, the effects on interest rates are in line with the previous ones, notably between those observed in the I_1 and in the I_a cases. Results for interest spreads and macro variables are less clear-cut: except for the real exchange rate, the responses in the two states are never statistically different between each other. All in all, results using I_2 confirm that the states obtained by applying Greenspan's views on gradualism (and a small variation around it) capture in the best way periods in which the FOMC adopted a gradualist approach and in which that strategy delivered a strong signal to the markets.

5 Conclusions

In this paper we investigate empirically the relevance of the gradualist approach of the Federal Reserve in the period 1990-2006 for the transmission of monetary policy. Using high-frequency identified shocks and a local projection framework, we find that the responses to US monetary shocks are stronger when the market perception of gradualism is high. This result comes from the intuition that, by acting gradually, the Fed gives a signal on the intended target rate adjustment, to which investors react. In particular, the difference in the response of interest rates in the high and low state is large for both short- and long-term rates, in line with the prediction made in Woodford (2003) that the perception of gradualism should allow a small adjustment of short rates to generate sizable long rate responses.

Our results can be related to the debate on the implementation of monetary policy. During the last tightening cycle, the Fed has usually been raising interest rates non-consecutively, i.e. at meetings coinciding with the release of the target rate projections of FOMC members. Currently, the Fed is rethinking its monetary policy framework, also considering being more active in non-projection meetings and questioning the future use of forward guidance. In this perspective, our paper highlights an effect of monetary policy implementation that is worth keeping in mind when designing the new monetary policy framework.

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