

# THE MOST EXPECTED THINGS OFTEN COME AS A SURPRISE: ANALYSIS OF THE IMPACT OF MONETARY SURPRISES ON THE BANK'S RISK AND ACTIVITY

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# The most expected things often come as a surprise: Analysis of the impact of monetary surprises on the bank's risk and activity

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## Abstract

In this paper, we analyse the link between monetary surprises and banks' activity and risk-taking. Some theoretical and empirical studies show that monetary easing increases banks' appetite for risk, affect credit allocation and bank's profitability. Our study adds to analyses of the monetary risk-taking channel considering monetary surprise, i.e. the impact of unexpected changes in monetary policy on bank's risk and activity. Using a dataset of US banks, we find that negative monetary surprises (higher increase or lower decrease of interest rates than expected) lead banks to take more risk, to grant more corporate loans than consumption loans, and to be more profitable. We complement the literature on the risk-taking channel and provide arguments that Central Banks can manage financial stability.

JEL Classification : E44, E58, G21.

**Keywords:** monetary surprise, financial stability, bank risk-taking, VAR model, dynamic panel regression

# 1 Introduction

While Federal Reserve communications has changed significantly over the past two decades and have become increasingly transparent, the financial markets are still prone to surprises. “*Surprises should occur only when the central bank has new information on the state of the economy which is not widely available, or where the central bank has a differing interpretation of the existing information from the rest of the economy, or finally where the central bank changes its preferences for reacting to economic information*” (Claus and Dungey, 2015, p.2). We can wonder about the implications of the Fed’s not meeting its commitments. In other words, while monetary policy decisions are now announced to the public, we can question the impact of monetary decisions if there is some surprise in their implementation.

This is an important issue since monetary policy has been proven to impact risk-taking of financial agents (Bernanke and Gertler 1989; Bernanke et al., 1996; Kiyotaki and Moore, 1997; Rajan, 2005; Adrian and Shin, 2009; De Nicolo et al. 2010; Diamond and Rajan, 2006, Alunbas et al., 2014; Ngambou Djatche, 2019). Moreover, central bank credibility induce banks to take riskier positions, what Montes and Peixoto (2014) call the “*paradox of credibility*”.

In this paper, we provide an empirical analysis of the impact of monetary policy surprise on bank’s activity and risk. We address the following main question: for financial stability purposes, should we only be interested in the (gross) changes in interest rates ? We do so by investigating two sub-questions: do unexpected changes into monetary policy translate into banks’ risks ? How monetary policy surprises affect bank’s activity (credit allocation and profit)? We aim at deepening the analysis the risk-taking channel of monetary policy, investigating the effects of changes in the monetary policy that are unanticipated by financial agents on bank’s risk and activity.

There are two reasons why we should expect that monetary policy surprise affects bank’s risk-taking behaviour and activity. The principal one is that monetary policy is a key factor that drives banks’ risk-taking behaviour (Smith, 2002; Gan, 2004; Jiménez et al., 2014; Adrian and Shin, 2009; Gambacorta, 2009; Dell’Ariccia et al., 2010; Borio and Zhu, 2012; Altunbas et al., 2014; Ioannidou et al., 2015; Ngambou Djatche, 2019). The other reason is that monetary policy decisions that come as a surprise, by causing sharp movements in assets price, may impact bank’s risk-taking and then lead to financial imbalance.

We face two major challenges when testing this relationship between monetary policy surprise and bank's risk and activity. The first one is related to measuring banks' risk-taking behaviour. While Gambacorta (2009) and Altunbas et al. (2014) use the change in the Expected Default Frequency ( $\Delta EDF$ ), which is a forward-looking indicator of credit risk, to proxy for bank risk-taking behaviour, we adopt a backward-looking approach of bank's risk measure and use the Z-score<sup>1</sup> as a proxy for bank risk. The Z-score is widely used to measure banks' financial soundness or insolvency (Roy, 1952; Boyd et al. 2006; Demirgüç-Kunt et al., 2008; Lepetit et al. 2008; Leaven and Levine, 2009; Lepetit and Strobel, 2013; Delis et al., 2014; Lepetit and Strobel, 2015). The lower the bank's Z-score the higher its risk of insolvency.

The second issue is the assessment of the monetary policy surprise. We follow Kim et al. (2016) and use a VAR analysis to estimate monetary policy surprise. As in Bhattarai et al. (2015), our VAR model includes the industrial production, the inflation measured by the private consumption expenditure index, market yield on U.S. 10-years Treasury Securities, the Fed effective rate. Contrary to Kim et al. (2016) who use the shadow Fed rate to account for unconventional measures, we include these unconventional measures in the VAR analysis. Hence, we follow MacDonald (2017) and include securities purchased by the Fed: 10-years Treasury securities, 10-years Mortgage backed securities, and Federal debt securities. From the VAR analysis, we extract the residuals of the Fed effective rate regression and refer to them as proxy of monetary surprise. We also extract residuals for regression on unconventional measure to account for unconventional monetary policy surprise. In other words, residuals extract from the regression on the Fed effective rate are considered as Fed rate surprise since they refer to changes in the Fed effective rate that are not anticipated by the financial agents. In the case of the fed effective rate, negative residuals are considered as positive surprises since they refer to lower increase or higher decrease in the Fed effective rate than expected. In the case of securities purchased, positive surprises are reflected into positive values of residuals since the latter refer to higher increase or lower decrease in the volume of purchased securities.

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<sup>1</sup>  $Z - score = [E(ROA) + CAR]/\sigma(ROA)$ , Where  $ROA$  is profits after tax/total assets,  $CAR$  is equity capital/total assets and  $\sigma(ROA)$  is the standard deviation of  $ROA$ . The underlying idea of the Z-score is that since bank is supposed to become insolvent when its current losses exhaust capital,  $CAR + ROA \leq 0$ , we can easily estimate the likelihood of insolvency by assuming that this likelihood refers to the probability that  $ROA \leq -CAR$  (or  $CAR < \pi$ ), with  $CAR$  the bank's capital to asset ratio,  $ROA$  its return on asset ratio (Lepetit and Strobel, 2015), and  $\pi$  its losses.

Using quarterly data for 259 US banks from 2001q2 to 2018q4, we evidence significant impacts of monetary policy surprises (i.e changes in the monetary policy that are not anticipated by financial agents) on the bank’s activity and risk-taking behaviour. The results show that when monetary interest rate decrease more or increase less than expected, banks tend to reduce their risk-taking translating into an increase of their soundness. However, positive monetary surprises translating into huge volume of mortgage backed securities or Federal agency debt securities held by the Fed, lead banks to take more risk. We also find that a negative monetary surprise (a lower decrease or a higher increase in interest rate than expected) leads banks to reduce the volume of credit with a change in the credit allocation. Following a negative monetary surprise, banks grant more loans to businesses than to households. Finally, we find that banks become more profitable in the event of a negative monetary surprise. In other words, banks endure profit losses (decrease of bank’s return on assets) when facing a positive monetary surprise (higher decrease or lower increase in interest rate than expected).

Our results allow for some recommendations about monetary and prudential policies. In light of our findings, monetary policy authorities should take account of the monetary policy surprises (positive or negative deviation of the interest rate from its expected path) when setting their monetary policy. Moreover, our findings call on prudential authorities to be more vigilant to monetary surprises since they could have significant impacts on financial stability.

The remaining paper is organized as follows. Section 2 provides a review of the literature on the risk-taking channel of monetary policy and on monetary surprises. Section 3 describes the data and the empirical approach adopted in this paper. Section 4 presents the results and Section 5 concludes the paper.

## 2 Literature review

Our paper relates to the monetary risk-taking channel. A plethora of studies focus on the impact of monetary policy on bank’s activity and risk. While risk-taking behaviour is identified as a major factor in financial fragility and to have its root causes in too loose monetary policy, it remains a complex concept. According to Ngambou Djatche (2019) risk-taking is “*an action or a decision that induces high asset volatility and depreciates bank soundness*”. Hence, it can translate into degradation of leverage

ratios, excessive lending or softening of credit standards, deterioration of loan quality, and decreased liquidity.

Common knowledge on the risk-taking channel of monetary policy establishes that a low interest rate environment has a negative effect on the determinants of agents' risk behaviour, risk perception and risk tolerance (Adrian and Shin, 2009; Borio and Zhu, 2012). Also, low interest rates trigger the softening of credit conditions and reduce banks' screening efforts (Ioannidou et al., 2015; Jiménez et al., 2014; Dell'Ariccia et al., 2010). There is a stream of empirical works on monetary risk-taking channel that supports this common view. It shows that monetary easing whets the bank's appetite for risk-taking and that this negative impact of a lower interest rate is amplified by a sustained period of low interest rates (Maddaloni et al., 2008; Gambacorta, 2009; Altunbas et al., 2014). When interest rates remain low for a prolonged period, banks are likely to take more risks as their revenues reduce. This leads to a search for yield as Rajan (2005) shows. Jiménez et al. (2014) find also that in a lower interest rate environment, well-capitalized banks take more risks than poorly capitalized banks. Ioannidou et al. (2015) find that an expansionary shock to the Fed interest rate softened lending conditions among banks in Bolivia. Ioannidou et al. (2015) show that liquid banks (with low levels of liquidity constraints) are more likely to take risks than those facing strong liquidity constraints.

However, there is also a positive (short-term) relationship between interest rates and bank portfolio risk Jiménez et al. (2014). An interest rate cut reduces the default risk of borrowers, since it reduces their interest expenses, which improves their repayment capabilities and reduces their and the bank's default probabilities. Besides, a low interest rate reduces the bank's opportunity cost (cost of hoarding liquidity) and, therefore, its risk incentive (Smith, 2002). Moreover, Higher interest rates may reduce the bank's franchise value and lead to more risk-taking (Gan, 2004). For instance, Kane (1989) find that higher interest rates cause a decrease in the bank's net worth and lead to "gambling for resurrection" as risky strategies become more attractive. Agur and Demertzis (2012) find that a rise in interest rates, by increasing the bank's refinancing cost, reduces the bank's profits. To compensate for this loss, the bank will choose riskier (more profitable) assets. Agur and Demertzis (2012) show that raising interest rates increases the bank's opportunity costs (cost of holding cash). Constrained by the fall in their net wealth, banks find risky alternatives and gambling for resurrection more attractive. That said, we can expect low interest rates to be beneficial to banks and to alleviate risk-taking behaviour.

These opposed results lead Ngambou Djatche (2019) to explore non-linearity in this channel. Using a non-dynamic panel threshold model, Ngambou Djatche (2019) evidence threshold value in the deviation of interest rate from the Taylor rule from which the effects of monetary policy on bank’ risk reverse. Bruno and Ngambou Djatche (2020) also show that the impact of monetary policy on bank’s risk depends on the risk sensitivity of the requirement capital ratio.

We contribute to this strand of the literature by deepening the analysis by examining the bank’s reaction to not monetary policy, but to monetary surprises.

Due to clear communications (through the FOMC), the Fed has increased its transparency. By doing so, the Fed expected to reduced policy uncertainty that may affect the agent’s behaviour in the event of monetary policy surprises. Therefore, banks may anticipate and adapt to monetary previsions. Therefore, it is clear that banks’ behaviour will be driven by monetary policy surprises, i.e. by unexpected changes in interest rates. Given that banks are not affected the same way by monetary contraction and softening, we expect them to react differently to positive and negative monetary surprise. We rely on a dynamic the panel model to analyse the “monetary surprise risk-taking channel”. To our knowledge, this is the first study to investigate the existence of a “monetary surprise risk-taking channel”. We control for macroeconomic conditions, the specific characteristics of the banks, the house price boom-bust cycle and excessive lending growth, to isolate the effects of monetary policy on banks’ risk.

### **3 Data and measure of bank risk-taking behaviour**

#### **3.1 Model and data**

##### **3.1.1 Data description**

We use quarterly data on 259 American banks from Bloomberg over the period 2001q2 to 2018q4. This long period is featured by periods of both economic expansion and economic downturn, and periods of high and low interest rates. Therefore, it allows a better assessment of the changes in banks’ activity and risk-taking behaviours. Our sample is heterogeneous in terms of bank size (assets), capitalisation (Tier1 ratio),

efficiency (income-to-cost ratio), asset quality and liquidity. Table 7 and 8 (see Appendix B) provide a description and a correlation matrix of our variables.

### Bank risk and activity variables

An essential element in our analysis is the variable for bank risk. The existing empirical literature use different measures of bank's risk: change in the Expected Default Frequency (EDF) (Gambacorta, 2009; Altunbas et al., 2014), change in credit standards (Ioannidou et al., 2007; Maddaloni et al., 2008 and Jiménez et al., 2014). We follows Ngambou Djatche (2019) and use the traditional Z-score to proxy for bank risk, using actual capital to asset ratio ( $CAR$ ) and  $ROA$ , and standard deviation of  $ROA$  estimated on the entire sample following Hesse and Cihak (2007) and Niu (2012):

$$Z - score = \frac{Car_t + ROA_t}{\sigma_{roa}}$$

where  $Car$  is equity capital/total assets,  $ROA$  is profits after tax/total assets and  $\sigma_{roa}$  is the standard deviation of  $ROA$  on the entire sample.

The underlying idea of the Z-score is that since the bank is supposed to become insolvent when its current losses exhaust capital,  $CAR + ROA \leq 0$ , we can estimate the likelihood of insolvency by assuming that this likelihood refers to the probability that  $ROA \leq -CAR$  (or  $CAR < \pi$ ), with  $CAR$  the bank's capital to asset ratio,  $ROA$  its return on asset ratio (Lepetit and Strobel, 2015), and  $\pi$  is the bank's losses. The Z-score or its log is used widely to measure bank financial soundness or bank insolvency (Roy, 1952; Boyd et al. 2006; Lepetit et al 2008; Lepetit et Strobel, 2013; Delis et al., 2014; Lepetit et Strobel, 2015; Fazio et al., 2018) and is inversely related to the probability the bank will become insolvent. The lower the bank's Z-score, the higher the risk of insolvency. According to Chiaramonte et al. (2016), 76% of banks failure can be well predicted by the Z-score.

This calculation of the Z-score has some limits. For an overview of the discussion, see Ngambou Djatche (2019).

Since bank risk is appreciated only when it materializes, bank risk-taking behaviour cannot be assessed at time. Therefore, the Z-score can be used to account for banks' risk behaviour through their capitalization, profitability and asset volatility. We would expect the bank's risk behaviour to affect its level of capitalization, profitability and



asset volatility, since the bank's financial decisions are related to capital structure and investment projects. Another advantage of the Z-score is that it is less data demanding and is easy to calculate since it requires only accounting data.

The identification strategy applied in this work is as follows: the risk-taking channel would suggest that bank risk increases (Z-score decreases) with a positive Fed effective rate surprise (lower increase or higher decrease of interest rate as expected). After controlling for macroeconomic shocks and the impact of some bank-specific factors, we can consider that any change in the Z-score refers mostly to the bank's risk-taking behaviour.

To check for robustness, we also use the 3-months probability of default as risk variable.

To perform our regression analysis, we need to include some key monetary, macroeconomic and bank variables that explain the variation in banks' risk.

### Monetary variables

Monetary variables gather short-term rate (changes in Fed effective rate,  $\Delta Fed$ ) and long-term rate (slope in the yield curve, 10 years bonds yield curve minus 2 years bonds yield curve) to account for the short and long-run relationship between monetary policy and banks' risk. To account for the accommodative or restrictive stance of the monetary policy, we estimate the Taylor gap following Gambacorta (2009), Altunbas et al. (2014) and Ngambou Djatche (2019). The Taylor gap is the deviation of the monetary rate from the Taylor rule based rate. We estimate the Fed Taylor rule rate following Taylor (1993):

$$i = r^* + \pi + 0.5(\pi - \pi^*) + 0.5y$$

Where  $r^*$  is the natural interest rate as estimated by Holston et al. (2017),  $\pi^*$  is the inflation target set at 2% and  $y$  is the output gap<sup>2</sup>. Since quarterly data have short frequency and do not smoothing of fluctuations in price levels, Taylor (1993) suggest that should be estimated as the moving average of the inflation on the 4 last quarters. We use the Gross Domestic Product (GDP) deflator as the inflation rate, expressed as the annual rate of change. The data for the calculation of the Taylor rule are

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<sup>2</sup> The output gap is the difference between the real GDP and the potential GDP, and expressed as a percentage of potential GDP,  $[(\text{Real GDP} - \text{Potential GDP}) / \text{Potential GDP}] * 100$ .

collected on the Fed and New-York Fed<sup>3</sup> websites. Figure 1, in appendix A, depicts the Fed effective rate and the Taylor rule rate.

To isolate the impact of conventional monetary policy shock on bank risk, from the potential influence of unconventional measures, we introduce a dummy UNC, which takes the value 1 from 2009q1 to 2018q4. This dummy refers to the period when the Fed introduced unconventional measures such as quantitative easing (purchase of 10 years mortgage backed securities, 10 years treasury securities, federal debts securities, etc.).

### **Macroeconomic variables**

It is important to control for macroeconomic variables. Banks are exposed to counterpart risk, i.e banks' financial position depends (at least partly) on the financial state of firms. We use GDP growth to control for the effect of business on banks' soundness. Hence, GDP growth proxies for the banks' risk that stems from the credit demand side. We follow Ngambou Djatche (2019) and include the St. Louis Fed Financial Stress Index (FSI) to capture the impact that system stress might have on bank soundness since banks operate in financial systems that, often, are subject to stress, which, in turn, could influence their own soundness. To control for borrower balance sheet channel we add housing price fluctuations based on changes in the Shiller national House Price (HP) index and asset price changes proxied by changes in the S&P index returns.

We are aware that the bank's overall risk can be affected also by unforeseen changes in the riskiness of its assets (risks occurring after their acquisition that are largely beyond the banks' control). Therefore, We enter the macroeconomic variables in the regressions at both one-quarter lag values and current values to account for their impact on the banks' risk-taking (at time of decision-making, i.e., at period  $t-1$ ) and soundness (i.e., at time  $t$ ).

To handle stationary concerns, with the exception of the Shiller national HP index, which is double differentiated, monetary and macroeconomic variables are first differentiated.

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<sup>3</sup> <https://www.newyorkfed.org/research/policy/rstar>

### Bank specific variables

Our database allows us to control for bank heterogeneity. First, we control for possible scale economies stemming from bank's size. We account for bank size using the log of total assets since banks. Second, we control for bank efficiency, measured as total income to total cost ratio (Delis and Kouretas, 2011; Boyd et al., 2006; Ngambou Djatche, 2019). We also include bank liquidity (Net loan to deposits ratio), since this appears to be relevant for banks' risk behaviour (Altunbas et al., 2014). Considering that banks' primary activity is lending, we expect large lenders to encounter increased assets and a decrease in their Z-score. We include lending growth to control for the impact of lending growth on bank's risk. Third, it is clear that well-capitalized banks can cope with credit losses. We include bank capital Tier 1 ratio to control for bank capitalization.

To address potential endogeneity problems, all bank-level variables enter with a one-quarter lag. Since bank risk could be subject to seasonal changes, we include seasonal dummies (SD). Appendix B, Tables 4 and 6 present the statistical description and correlation matrix of our variables.

### 3.2 Econometric analysis

Existing empirical studies try to assess risk-taking using a linear General Method of Moment (GMM) (Altunbas et al., 2014; Gambacorta, 2010) model and non-dynamic panel threshold model (Ngambou Djatche, 2019).

The objective of the present study is to analyse the potential effects of monetary surprises on banks risk-taking. We do so by regressing bank's risk variables, the Z-score on monetary surprises variable. We control for macroeconomic and bank-specific variables, using GMM to estimate the dynamic panel model (see Arellano and Bover, 1995).

Our analysis consist of two steps. In the first step, we estimate monetary surprise through a VAR model. We follow Kim et al. (2016) and estimate Fed monetary surprise, i.e the changes in the Fed effective interest rate that are not predicted by fundamentals. To do so, we use VAR analysis and extract residuals from the equation of Fed effective rate. The residuals are considered as conventional monetary surprise. In the second step, we estimate the impact of monetary surprises on bank's risk and activity using a dynamic panel regression.

### 3.2.1 Estimation of the monetary surprise: the VAR model

Monetary surprises are explored for different purposes in the literature (Claus and Dungey, 2015; Jansen and Zervou, 2015; Grigoli and al., 2020). Grigoli and al. (2020) consider monetary surprises as [the absolute value of] the deviation of the individuals' expected federal funds rate from the actual rate announced at the time of the central bank meeting. Monetary policy surprise is also defined by Jansen and Zervou (2015) as “*the difference between the federal funds rate target announced at time  $t$ ,  $\tilde{r}_t$ , from the public's previous period expectation about the federal funds rate target announcement at time  $t$* ” (p.5).

In line with Jansen and Zervou (2015) and defined as monetary policy surprise the change in the fed effective rate that is not anticipated by the markets. We do so by using a VAR model.

The objective of estimating a VAR on quarterly US data from 2001q2 to 2018q4 is to extract indicators of conventional and unconventional monetary policy that are not predicted by any model.

The use of the VAR allows, while capturing the relationships between the variables, to predict a component not explained by the model (the error term associated with the variable of interest). We refer to “monetary surprise”, following Kim et al. (2016), as the component of monetary policy that the model does not predict.

As a result, our panel estimation will not be biased since it will only take into account the monetary surprises that the agents could not anticipate. In fact, the anticipation of the Fed's actions leads to portfolio movements even before the purchases are made. Announcement effects, as studied in the literature (Chen et al. (2012), Bowman et al. (2015), etc.), are important in the movement of capital and thus of asset prices.

Our equation captures the indicators that the central bank can use to guide its monetary policy and the monetary policy and the variables it acts on. The choice of our variables is similar to Bhattarai et al (2015). Our model includes the industrial production index (indpro) which summarizes the country's output growth with quarterly data. We also consider the consumer price index (CPI) and Private Consumption Expenditure (pcepi) as a proxy for the inflation. This indicator is used by the Fed as an inflation target. In addition, we add to our model the sovereign yield on 10-year U.S. Treasuries (gs10y) as well as the S&P500 equity index (sp500) to reflect the financial effects of monetary policy.

We also use quantitative indicators of unconventional monetary policy. While Bhattarai et al (2015) use the central bank's holding of securities, we consider the composition of the Fed's balance sheet following the Fed's balance sheet following its unconventional interventions in the markets. Following Macdonald (2017), we retain the various purchases of the US central bank. We therefore consider the following securities in millions of dollars with a maturity of 10 years or more: treasury bills (treas10y), mortgage-backed securities (mbs10y) and agency securities (fedd10y). We also add the central bank's short-term interest rate (fedrate). Taking

into account the conventional and unconventional instruments in our model allows us to capture the full range of monetary shocks that occurred between 2000 and 2018.

From the VAR estimation, we extract the residuals inherent to these four monetary policy indicators. We will refer to these residuals as the unanticipated change in the monetary policy (the monetary surprises).

All variables are taken from the Federal Reserve website.

Our model is presented in the following reduced form:

$$Y_t = A_0 + A(L)Y_t + \epsilon_t$$

We estimate the VAR model with 2 lags as jointly recommended by the AIC and HQIC criteria (see Table 1).

We then extract the residuals of each monetary instruments with a particular interest on the residual of the Fed effective rate. As reminder, we refer to these residuals as “monetary surprise”, i.e changes in the Fed effective rate that are not anticipated by financial agents. Figure 2 in appendix A gives a bird’s eye view of the “monetary surprise”.

Table 1: Selection order criteria for VAR analysis

| Selection order<br>criteria | Number of obs=71<br>Sample : 2001q2-2018q4 |                |                  |                   |                 |                  |                |                |
|-----------------------------|--|----------------|------------------|-------------------|-----------------|------------------|----------------|----------------|
|                             | LL   | LR             | df               | p                 | FPE             | AIC              | HQIC           | SBIC           |
| 0                           | -3398                                      | 6.500e+31      | 95.95            | 96.05             | 96.20           |                  |                |                |
| 1                           | -2549                                      | 1698           | 64               | 0                 | 1.600e+22       | 73.84            | 74.75          | 76.1362*       |
| 2                           | -2417                                      | 264.45*        | 64               | 0                 | 2.6e+21*        | 71.9199*         | 73.6434*       | 76.25          |
| Endogenous                  | $\Delta Indpro$                            | $\Delta pcepi$ | $\Delta fedrate$ | $\Delta treas10y$ | $\Delta mbs10y$ | $\Delta fedd10y$ | $\Delta gs10y$ | $\Delta sp500$ |
| Exogenous                   | cons                                       |                |                  |                   |                 |                  |                |                |

$\Delta Indpro$ : changes in industrial production index;  $\Delta pcepi$ : change in the private consumption expenditure index;  $\Delta fedrate$ : change in the Fed effective rate;  $\Delta treas10y$ : change in the volume of 10-year treasury securities held by the Fed;  $\Delta mbs10y$ : change in the volume of 10-year mortgage backed securities held by the Fed;  $\Delta fedd10y$ : change in the volume of 10-year federal agency debt securities held by the Fed;  $\Delta gs10y$ : change in the sovereign yield on 10-year U.S. Treasuries;  $\Delta sp500$ : change in the S&P500 equity index.

### 3.2.2 Estimation of effects of monetary policy surprise on bank’s risk

The existing empirical studies on the risk-taking channel mainly identify the link between change in monetary policy and banks’ risk (Gambacorta, 2009; Altunbas et al. 2014; Ioannidou et al., 2015, Ngambou Djatche, 2019). These studies consider the monetary policy as a whole. Here we aim at disentangle the risk-taking stemming from

a surprise introduced the Fed when setting its policy from the risk-taking driven by expected changes in monetary policy.

Hence, existing studies ignore the possible reversal effects of monetary policy on bank risk. Changes in monetary policy may positively or negatively surprise financial agents, leading to changes in the behaviour of the latter. We could then expect that the impact of monetary policy on bank risk changes according to the nature of the monetary surprise.

We explore this impact through a dynamic panel regression. This is a novel approach to empirically testing the monetary policy risk-taking channel.

The data generating process for the threshold analysis can be written as follows:

$$\mathbf{Risk}_{i,t} = \lambda_i + \alpha \mathbf{Risk}_{i,t-1} + \sum_{j=0}^1 \delta_j \Delta \mathbf{ResMP}_{t-j} + \sum_{j=0}^1 \beta_j \mathbf{X}_{1,t-j} + \phi \mathbf{X}_{2,t-1} + \mathbf{UNC} + \sum_{j=1}^4 \eta_j \mathbf{SD}_t + \varepsilon_{i,t}$$

Where  $\mathbf{ResMP}_t$ ,  $\mathbf{X}_{1t}$  and  $\mathbf{X}_{2t}$  are respectively the monetary surprise variable, other macroeconomic variables and banks specific variables,  $\mathbf{UNC}$  is a dummy referring to period of unconventional measures (2009q1 to 2018q4), and  $\mathbf{SD}$  are seasonal dummies.

Our variable of interest here is the of the Fed effective rate surprise ( $\mathbf{ResFedrate}$ ) which refers to changes in the Fed effective rate that are not anticipated by financial agents. Negative surprise (positive values of  $\mathbf{ResFedrate}$ ) means that either Fed effective rate increases more or decreases less than expected. Conversely, when either Fed effective rate increases less or decreases more than expected, the monetary surprise is considered as positive. Since the Fed effective rate is an instrument aiming at steering the economy, any deviation from its expected path could also impact the behaviour of financial agents. For that reason, we could expect that unexpected changes in monetary interest rate have different impacts given the nature of the surprise. In other words, the effects of a decrease of interest rate may differ given the deviation of the Fed effective rate from its expected path.

It would seem useful to analyse the effect of monetary surprise on bank risk since monetary policy seems to have unclear effects on banks' risk-taking (see Ngambou Djatche (2019) for more detail on this point). The results in Lamers et al. (2016) show that monetary easing increases bank profitability and, thus, reduces the banks' incentives to take more risk. An accommodative monetary policy is beneficial for banks that rely on debt financing, since it lowers interest charges and increases their profit. It is obvious that banks' behaviour will depend on the gains or losses due to lower

interest rates. Thus, there will be a degree of interest rate reduction that will not lead to more risk-taking by the banks because the losses incurred in their lending operations are offset by their lower financing costs.

## 4 Results and discussion

In this section, we present and discuss the results of our threshold analysis and check the robustness of our estimations.

### 4.1 Impacts of monetary surprises on bank's risk and activity

In this subsection, we will successively assess the impact of monetary surprise on the bank's risk, on the one hand, and on the bank's activity on the other hand.

#### 4.1.1 Monetary surprises and bank's risk

Table 2 presents the results of the panel analysis. Regression 1 estimates the impacts of Fed effective rate surprise on bank's risk.

An interesting result is that the monetary surprise has significant impacts on banks' soundness. Regression 1 shows that the estimate for  $ResFedrate_{t-1}$  is negative and significant. This implies that a positive surprise (lower increase or higher decrease of interest rate than expected) fosters bank's soundness. In other words, when the increase (decrease) of the Fed effective rate is 1% smaller (higher) than expected, the bank's soundness increase 0.506 unit. A looser monetary policy induces a decrease in bank's risk-taking. Hence, the Fed can foster bank's soundness by "beating the market". While the market expects a decrease of interest rate, the Fed can go further and decrease interest rate further than expected, refraining bank's risk-taking. Furthermore, while the market expect an increase of interest up to a given level, the Fed can weakly increase interest rate such that there is a positive shock for financial agents.

Since the Fed uses unconventional monetary policy, we analyse the impact of surprises stemming from such measures on the bank's risk. Regression 2 to regression 4 estimate the impacts of the surprises of Fed unconventional measures on bank's risk. Regression 2 assess the effects of Fed Treasury purchase surprise on bank's risk. Regression 3 deals with the effects of Fed Mortgage-backed securities purchases surprise on bank's

risk. And regression 4 estimates the impacts of the surprise of the Fed holding 10-year maturity Federal agency debt securities on bank's risk.

Table 2: Estimation of effects of conventional monetary surprise on bank's risk

| VARIABLES              | (1)<br>Bank's Z-score |
|------------------------|-----------------------|
| $Z - score_{t-1}$      | 1.075***<br>(0.0188)  |
| $ResFedrate_{t-1}$     | -0.506**<br>(0.233)   |
| $ResFedrate_t$         | 0.608<br>(0.422)      |
| $\Delta Fedrate_{t-1}$ | 0.445<br>(0.315)      |
| $\Delta Fedrate_t$     | -0.648<br>(0.428)     |
| unc                    | 0.308**<br>(0.134)    |
| Banks FE               | Yes                   |
| Controls               | Yes                   |
| SD                     | Yes                   |
| Observations           | 17,871                |
| Number of no           | 259                   |
| Number of instruments  | 81                    |
| AR(2)                  | 0.222                 |
| Hansen test            | 0.480                 |

Notes: This table reports results of the dynamic panel regression. Robust standard errors in parentheses, \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . *ResFedrate*: Fed effective rate surprise (residuals of Fed effective rate extracted from the VAR analysis). *ΔFedrate*: Change in the Fed effective rate. The dummy variable "UNC" take the value 1 between 2009q1 and 2018q4, and 0 otherwise and refers to a period of unconventional monetary policy measures.

Looking at unconventional measures, we observe that positive surprises (higher volume purchased than expected) lead to an increase in the bank's risk (Table 3). One unit more of MBS or Federal agency debt held than expected leads to a decrease of bank's soundness (a decrease of respectively  $3 * 10^{-6}$  and 0.002 units). Therefore, banks tend to take more risk when the Fed hold more MBS and Federal agency debt than expected. Hence, holding lesser than expected may refrain bank's risk-taking.

Our findings confirm that the deviation of the monetary policy from its expected level affects bank's risk-taking behaviour. We show that banks differently behave according to the nature of the monetary surprise. Thus, a positive surprise on the monetary rate, i.e lower increase or higher decrease in interest rate than expected, is desirable.



Table 3: Estimation of effects of unconventional monetary surprise on bank's risk

| VARIABLES              | (2)<br>Bank's Z-score     | (3)<br>Bank's Z-score     | (4)<br>Bank's Z-score   |
|------------------------|---------------------------|---------------------------|-------------------------|
| $Z - score_{t-1}$      | 1.063***<br>(0.0251)      | 1.074***<br>(0.0180)      | 1.083***<br>(0.0235)    |
| $ResTreas_{t-1}$       | -3.51e-06<br>(5.01e-06)   |                           |                         |
| $ResTreas_t$           | 1.56e-05*<br>(8.07e-06)   |                           |                         |
| $\Delta Treas_{t-1}$   | 1.21e-05*<br>(6.23e-06)   |                           |                         |
| $\Delta Treas_t$       | -1.92e-05**<br>(8.67e-06) |                           |                         |
| $ResMbs_{t-1}$         |                           | -3.24e-06*<br>(1.69e-06)  |                         |
| $ResMbs_t$             |                           | 5.37e-06**<br>(2.54e-06)  |                         |
| $\Delta Mbs_{t-1}$     |                           | 4.27e-06***<br>(1.53e-06) |                         |
| $\Delta Mbs_t$         |                           | -3.74e-06*<br>(1.94e-06)  |                         |
| $ResFedd10y_{t-1}$     |                           |                           | -0.00210*<br>(0.00108)  |
| $ResFedd10y_t$         |                           |                           | 0.00111<br>(0.00114)    |
| $\Delta Fedd10y_{t-1}$ |                           |                           | 0.000884*<br>(0.000525) |
| $\Delta Fedd10y_t$     |                           |                           | -0.000490<br>(0.000324) |
| unc                    | 0.525**<br>(0.211)        | 0.386**<br>(0.157)        | 0.457***<br>(0.149)     |
| Banks FE               | Yes                       | Yes                       | Yes                     |
| Controls               | Yes                       | Yes                       | Yes                     |
| SD                     | Yes                       | Yes                       | Yes                     |
| Observations           | 17,871                    | 17,871                    | 17,612                  |
| Number of no           | 259                       | 259                       | 259                     |
| Number of instruments  | 81                        | 81                        | 82                      |
| AR(2)                  | 0.605                     | 0.706                     | 0.837                   |
| Hansen test            | 0.117                     | 0.462                     | 0.09                    |

Notes: This table reports results of the dynamic panel regression. Robust standard errors in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. **ResFedrate**: Fed effective rate surprise (residuals of Fed effective rate extracted from the VAR analysis). **ΔFedrate**: Change in the Fed effective rate. **ResTreas**: Fed 10-years Treasury securities holding surprise (residuals of Treasury securities holding extracted from the VAR analysis). **ΔTreas10y**: Change in the Fed 10-years Treasury securities holding. **Resmbs10y**: Fed 10-years mortgage backed securities holding surprise (residuals of mortgage backed securities holding extracted from the VAR analysis). **ΔMbs10y**: Change in the Fed 10-years mortgage backed securities holding. **ResFedd10y**: Fed holding 10-year maturity Federal agency debt securities surprise (residuals of Fed holding 10-years maturity Federal agency debt securities extracted from the VAR analysis). **ΔFedd10y**: Change in the Fed holding 10-year maturity Federal agency debt securities. The dummy variable “UNC” take the value 1 between 2009q1 and 2018q4, and 0 otherwise and refers to a period of unconventional monetary policy measures.

In such a situation, banks benefit either from lower funding costs (in case of lower increase than expected) or reduced loan loss provision (in case of higher decrease of interest rate than expected). Positive impacts of lower increase of interest rate than expected on bank's risk (decrease of bank's risk) find support in findings of Gan (2004) and Agur and demertzis (2012). As Gan (2004) shows, increasing interest rate may reduce the bank's franchise value and lead to more risk-taking. Agur and Demertzis (2012) find that a rise in interest rates, by increasing the cost of bank financing, reduces bank profits. To compensate for this loss, banks turn to riskier (more profitable) assets. Positive impacts of lower increase of interest rate than expected on bank's risk (decrease of bank's risk) is consistence with findings of Deutsche Bundesbank (2018) that "*low interest rates can also have a positive impact on profitability, e.g. in the form of reduced loan loss provisions*" (p.27).

There are two important implications of our study. First, monetary policy authorities should be aware that of the surprises (positive or negative deviation of monetary measures from their expected path) they create may differently influence financial agents' behaviours. Second, our findings call on prudential authorities to be more vigilant to the monetary surprises since they could have different impact on financial stability. Therefore, since monetary policy, as well as prudential policy, may affect banks' behaviour, risk-taking and crisis prevention should be the tasks of both the regulatory and the monetary authorities. The proactive view of monetary policy (Borio and White, 2004; Woodford, 2012) find support in our conclusion.

Furthermore, our results show that banks were impacted positively by the period of unconventional policy measures: the coefficient of the dummy UNC is positive and significant. This result is opposed to findings by Ngambou Djatche (2019), and by Plescau and Cocris (2016) that banks' risk-taking increases with Central Banks' use of unconventional instruments.

#### **4.1.2 Monetary surprises and bank's activity**

Monetary surprises may affect the bank's activity by impacting the volume of loan granted, the credit allocation between enterprises and household, and bank's profitability. The aim of this subsection is to determine the impact of monetary surprise on these three keys elements of bank's activity. We particularly focus on how

the Fed effective rate surprise affect bank's activity. Table 4 gives a bird's eye view on this impact.

The main result is that the monetary surprise has significant impacts on banks' activity and profitability. Regression 5 shows that the estimate for  $ResFed_{t-1}$  is negative and significant. This implies that a positive surprise (lower increase or higher decrease in interest rate than expected) encourage banks to grant more loans. In other words, when the increase (decrease) of the Fed effective rate is 1% smaller (higher) than expected, the bank's credit activity increases of about 12%.

Table 4: Estimation of effects of monetary surprises on bank's activity

| VARIABLES                       | (5)<br><i>Loangrowth<sub>t</sub></i> | (6)<br><i>Business<sub>t</sub></i> | (7)<br><i>Roa<sub>t</sub></i> |
|---------------------------------|--------------------------------------|------------------------------------|-------------------------------|
| <i>Loangrowth<sub>t-1</sub></i> | 1.009***<br>(0.0232)                 |                                    |                               |
| <i>Business<sub>t-1</sub></i>   |                                      | -0.204<br>(0.277)                  |                               |
| <i>Roa<sub>t-1</sub></i>        |                                      |                                    | 1.040***<br>(0.0330)          |
| <i>ResFedrate<sub>t-1</sub></i> | -12.65*<br>(7.53)                    | 74.13**<br>(33.90)                 | 0.443*<br>(0.245)             |
| <i>ResFedrate<sub>t</sub></i>   | 1.29<br>(16.7)                       | 46.26<br>(104.2)                   | -0.128<br>(0.520)             |
| $\Delta Fedrate_{t-1}$          | 0.720<br>(11.43)                     | 27.62<br>(69.26)                   | -0.224<br>(0.396)             |
| $\Delta Fedrate_t$              | -2.56<br>(9.76)                      | -66.65<br>(57.06)                  | -0.0842<br>(0.384)            |
| unc                             | -3.808<br>(4.492)                    | 11.38<br>(29.57)                   | -0.0890<br>(0.299)            |
| Banks FE                        | Yes                                  | Yes                                | Yes                           |
| Controls                        | Yes                                  | Yes                                | Yes                           |
| SD                              | Yes                                  | Yes                                | Yes                           |
| Observations                    | 17,871                               | 17,871                             | 17,871                        |
| Number of no                    | 259                                  | 259                                | 259                           |
| Number of instruments           | 79                                   | 79                                 | 76                            |
| AR(2)                           | 0.358                                | 0.154                              | 0.872                         |
| Hansen test                     | 0.786                                | 0.453                              | 0.619                         |

Notes: This table reports results of the dynamic panel regression. Robust standard errors in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. *ResFedrate*: Fed effective rate surprise (residuals of Fed effective rate extracted from the VAR analysis).  $\Delta Fedrate$ : Change in the Fed effective rate. *Loangrowth* is the quarterly growth of loan. *Business* proxy for credit allocation between enterprises and households and is computed as the ratio  $\frac{Commercial\ Loans}{Consumption\ Loans}$ . *Roa* is the return on asset and proxies for bank's profit. The dummy variable "UNC" take the value 1 between 2009q1 and 2018q4, and 0 otherwise and refers to a period of unconventional monetary policy measures.

This result can be explained by the fact larger decrease in interest rate than expected is similar to monetary accommodation. Therefore, banks tend to grant more loans.

This result is consistent with the bank lending channel of monetary policy. Positive monetary surprise ensure the borrower a better creditworthiness than expected, then the number of borrowers on the credit market increase (Bernanke & Gertler, 1989; Kiyotaki & Moore, 1997). As interest rates are lower than expected, assets price is higher and borrowers become richer. For the same amount of assets used as collateral, borrowers access a larger amount of financing. As the overall borrower's solvability ("fictitiously") improves, the supply of credit increases and funding costs reduce (Bernanke and Gertler, 1989).

The coefficient on business is positive and significative. Monetary surprise affect credit allocation. A negative surprise (lower decrease or higher increase in interest rate than expected) leads banks to grant more credit to enterprises than to households. When the increase (decrease) of the Fed effective rate is 1% higher (smaller) than expected, banks grant 74% more credit to enterprises than to households. We can explain it by the fact that the rigidity of rates on loans granted to households would reduce bank margins following the rise in monetary rates. Therefore, a negative monetary surprise (assimilated to a monetary contraction) would have a stronger effect on the consumers balance sheets, encouraging banks to reduce credit to households in favour of corporate credit. This is consistent with Den Haan et al. (2007) who examine the behaviour of banks loan portfolio components (business loans, mortgages, and household loans) in the event of monetary and productivity shocks. Using VAR models, they show that, following a monetary contraction, mortgages and household loans decline considerably, while the response of credit to enterprises is positive.

Monetary surprise positively impact bank's profit. A negative surprise (higher increase or lower decrease in interest rate than expected) entails profit gains for banks. When the decrease (increase) of the Fed effective rate is 1% higher (smaller) than expected, banks face about 0.4% profit losses. A decrease of interest rate more than expected triggers decrease of interest rate on banks assets (while interest rate on deposits is constant), leading to a tightening of the bank's margin. This finding is consistent with Alessandri and Nelson (2015) and comforts Borio et al. (2017) and Altavilla et al. (2018) findings. Alessandri and Nelson (2015) find that a 100 basis point rise in short rates would raise the operating profit margin by around 0.04 percentage points per quarter. Altavilla et al. (2018) find that a reduction in the short-term interest rate or a flattening of the yield curve tends to reduce bank profitability.

Our results have some important implications; therefore, we need to test their robustness.

## 4.2 Robustness check

### 4.2.1 Controlling for potential joint impact of monetary surprises

In the previous regressions, we tested the impact of monetary surprises solely. Since conventional and unconventional monetary measures are taken together, the impact of each measure may be influenced by other measures. We test if the impact Fed effective rate surprises remains robust to the potential impact of other unconventional monetary surprises. Table 5 presents the results of this robustness test.

Table 5: Robustness on joint impact of conventional and unconventional monetary surprises

| VARIABLES             | (5)<br>$Z - score_t$     |
|-----------------------|--------------------------|
| $Z - score_{t-1}$     | 1.063***<br>(0.0203)     |
| $ResFedrate_{t-1}$    | -0.551**<br>(0.272)      |
| $ResFedrate_t$        | 0.0337<br>(0.293)        |
| $ResTreas_{t-1}$      | -5.69e-06*<br>(3.43e-06) |
| $ResTreas_t$          | -8.30e-06*<br>(4.99e-06) |
| $ResMbs_{t-1}$        | 1.98e-06<br>(1.66e-06)   |
| $ResMbs_t$            | 1.19e-06<br>(1.48e-06)   |
| $ResFedd10y_{t-1}$    | -0.000875<br>(0.00142)   |
| $ResFedd10y_t$        | 0.00129<br>(0.00115)     |
| unc                   | 0.662***<br>(0.205)      |
| Banks FE              | Yes                      |
| Controls              | Yes                      |
| SD                    | Yes                      |
| Observations          | 17,871                   |
| Number of no          | 259                      |
| Number of instruments | 81                       |
| AR(2)                 | 0.527                    |
| Hansen test           | 0.252                    |

Notes: This table reports results of the dynamic panel regression. Robust standard errors in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. **ResFedrate**: Fed effective rate surprise (residuals of Fed effective rate extracted from the VAR analysis). **ΔFedrate**: Change in the Fed effective rate. **ResTreas**: Fed 10-years Treasury securities holding surprise (residuals of Treasury securities holding extracted from the VAR analysis). **ΔTreas10y**: Change in the Fed 10-years Treasury securities holding. **Resmbs10y**: Fed 10-years mortgage backed securities

holding surprise (residuals of mortgage backed securities holding extracted from the VAR analysis).  $\Delta Mbs10y$ : Change in the Fed 10-years mortgage backed securities holding.  $ResFed10y$ : Fed holding 10-year maturity Federal agency debt securities surprise (residuals of Fed holding 10-years maturity Federal agency debt securities extracted from the VAR analysis).  $\Delta Fed10y$ : Change in the Fed holding 10-year maturity Federal agency debt securities. The dummy variable “UNC” take the value 1 between 2009q1 and 2015q4, and 0 otherwise and refers to a period of unconventional monetary policy measures.

Assessing the impact of monetary surprises at the same time does not fade out the effect of Fed effective rate surprise on bank’s risk. Including all the conventional and unconventional monetary measure at the same time, we find that the Fed effective rate surprises is still negatively related to bank’s soundness. An 1% smaller (higher) increase (decrease) of the Fed effective rate than expected lead to an increase of the bank’s soundness (a decrease bank’s risk) of about 0.55 units.

Besides Fed effective rate surprise, only the treasury holding surprise has a significant impact on bank’s risk. A smaller increase or an higher decrease in the treasury holding lead banks to take more risk.

#### 4.2.2 Alternative measure of bank’s risk

The preceding results prove significant impacts of monetary surprises on bank risk proxied by the Z-score. In this section, we provide some robustness tests, using different bank’s risk measures. First, we use the 3-months probability of default (henceforth PD3m) that measure the probability that the banks default within the 3 next months. While the Z-score is backward-looking risk variable, the PD3m is a forward-looking risk variable.

Table 6 presents the regression results.

Modifying the bank’s risk variable does not change the impact of the Fed effective rate surprise. We find that the Fed effective rate surprises is still positively related to bank’s risk. Following an 1% higher (smaller) increase (decrease) of the Fed effective rate than expected the bank’s probability of default within 3 months increases of about 0.01%.

Table 6: Robustness test on bank's risk

| VARIABLES              | (9)<br>$PD3m_t$         |
|------------------------|-------------------------|
| $PD3m_{t-1}$           | 0.797***<br>(0.0885)    |
| $ResFedrate_{t-1}$     | 0.00989***<br>(0.00378) |
| $ResFedrate_t$         | -0.00177<br>(0.0124)    |
| $\Delta Fedrate_{t-1}$ | -0.00681<br>(0.00741)   |
| $\Delta Fedrate_t$     | -3.68e-05<br>(0.0107)   |
| unc                    | -0.00355<br>(0.00738)   |
| Banks FE               | Yes                     |
| Controls               | Yes                     |
| SD                     | Yes                     |
| Observations           | 17,871                  |
| Number of no           | 259                     |
| Number of instruments  | 81                      |
| AR(2)                  | 0.158                   |
| Hansen test            | 0.12                    |

Notes: This table reports results of the dynamic panel regression. Robust standard errors in parentheses, \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . **ResFedrate**: Fed effective rate surprise (residuals of Fed effective rate extracted from the VAR analysis).  **$\Delta Fedrate$** : Change in the Fed effective rate. The dummy variable "UNC" take the value 1 between 2009q1 and 2018q4, and 0 otherwise and refers to a period of unconventional monetary policy measures.

We can conclude that the Fed effective rate surprises has a negative impact on bank soundness. Hence, when banks are surprised by higher level of interest rate than expected, they tend to take more risk.

## 5 Conclusion

In this paper, we aim at contributing to empirical research on the monetary policy risk-taking channel. Through dynamic panel regressions, we assess the impact of monetary surprises (unexpected changes in monetary policy) on bank's risk and activity. Although much empirical research on the monetary policy risk-taking channel already exist, our paper deepen the analysis using monetary surprises to explore this channel.

We found that Fed effective rate surprises are negatively related to bank's risk. Higher increase or lower decrease in interest rate than expected lead banks to take more risk.

These surprises also affect banks' lending activity. Loan growth decreases with higher increase or lower decrease in interest rate than expected, banks tend to grant more commercial loans than consumption loans. In sum, our results suggest that, for banks' risk-taking behaviour concerns, if the change in monetary interest rate is important, the surprise (unanticipated change by financial agents) which follows this change is relevant.

Moreover, the existing literature related to monetary policy is in favour of a transparent monetary policy. However, it appears that monetary authorities can drive financial agents behaviour by keeping their action a bit mysterious. Our results show that some surprise in the conduct of monetary policy is desirable since it can promote bank's soundness, and hence financial stability. Furthermore, the inclusion of a financial stability side to Central Banks' objectives seems to find a rationale in our results. In the same vein, according to our findings, monetary authorities should pay more attention to financial stability when setting interest rates and suggest that banking supervisors should consider the potential effects of monetary surprises when conducting banking supervision.

However, our estimation of monetary surprises through VAR has some caveats. The important one is related to the identification of the monetary surprise introduced by the central bank. It may be possible that what is unexpected by markets is also unanticipated by the central bank as well. Therefore the development of a novel approach to better estimate monetary surprises is needed.



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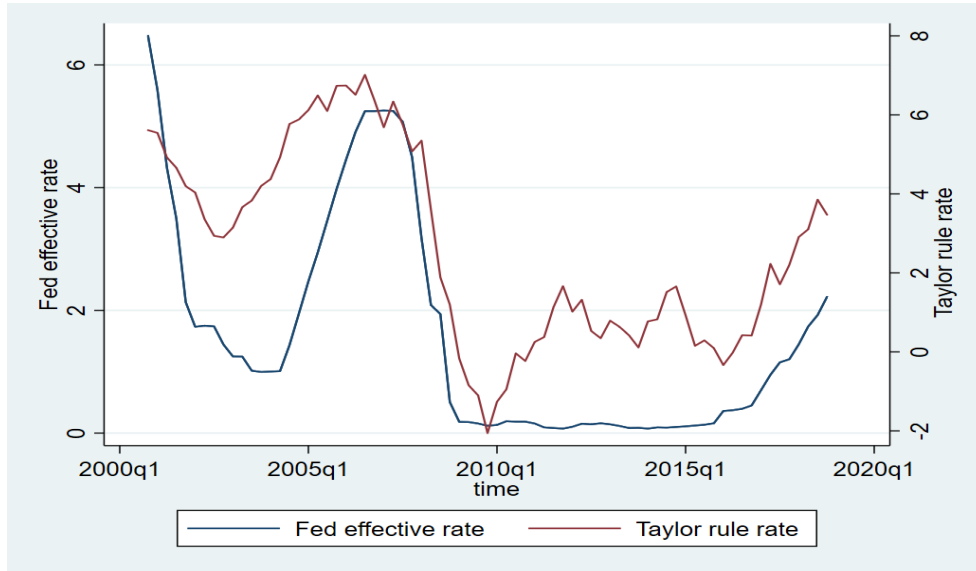
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# Appendices

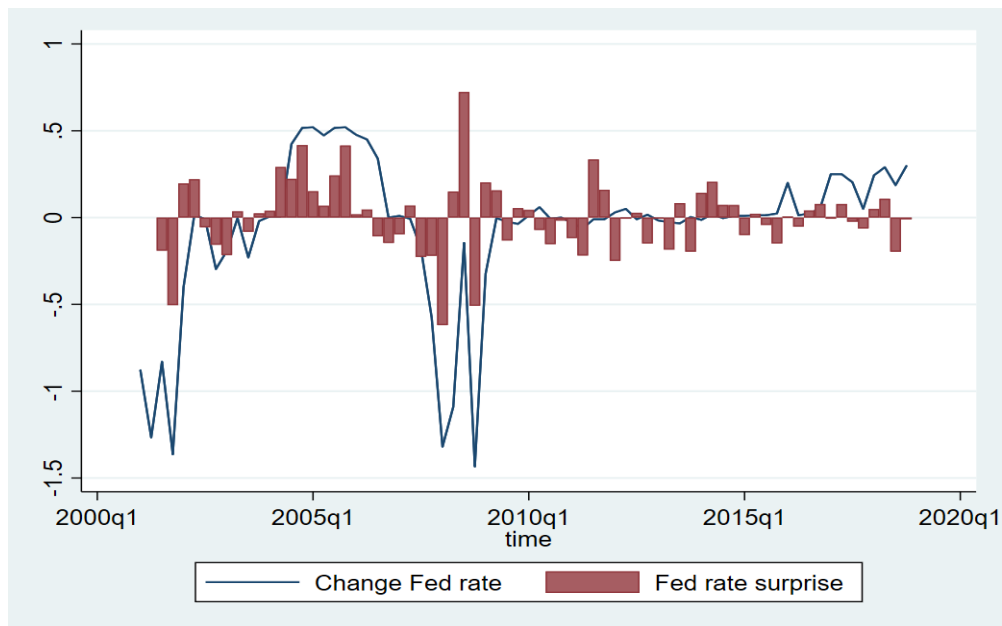
## Appendix A Fed effective rate, Taylor rule and monetary policy surprise

Figure 1: Fed effective interest rate and Fed Taylor rule rate



Note: The Fed Taylor rule rate is computed as follow  $i = r^* + \pi + 0.5(\pi - \pi^*) + 0.5y$ , where  $r^*$  is the natural interest rate as estimated by Holston et al. (2017),  $\pi^*$  is the inflation target set at 2% and  $y$  is the output gap.

Figure 2: Changes in Fed effective interest rate and Fed effective rate surprise



Note: The Fed effective rate surprise refers to residuals of change in Fed effective rate extracted from the VAR analysis. Negative value indicates positive monetary surprise, i.e. when Fed rate increases lower or decreases deeper than expected by markets.

## Appendix B

**Table 7** Summary statistics of the variables used in the regressions (USA banks data, 2001Q2-2018Q4)

| Variable             | Obs    | Mean      | Std.Dev. | Min      | Max    |
|----------------------|--------|-----------|----------|----------|--------|
| Z-score              | 18,907 | 3.202     | 2.786    | -5.671   | 20.99  |
| PD3m                 | 18,907 | 0.000337  | 0.00406  | 1.00e-09 | 0.186  |
| Liquidity            | 18,907 | 87.85     | 18.69    | 19.92    | 892.1  |
| Loan growth          | 18,907 | 10.19     | 17.50    | -62.19   | 286.7  |
| Tier1                | 18,907 | 12.71     | 3.706    | 2.650    | 136    |
| Size                 | 18,907 | 7.714     | 1.638    | 4.153    | 14.78  |
| Efficiency ratio     | 18,907 | 64.69     | 23.18    | -378.3   | 1700   |
| ROA                  | 18,907 | 0.877     | 0.820    | -15.25   | 7.198  |
| Business             | 18,907 | 3.792     | 14.06    | 0.00794  | 709.9  |
| GDP growth           | 18,907 | 0.968     | 0.669    | -1.952   | 2.244  |
| $\Delta Fedrate$     | 18,648 | -0.0591   | 0.425    | -1.433   | 0.520  |
| Taygap               | 18,907 | -1.023    | 1.334    | -4.335   | 2.176  |
| $\Delta Shiller\ hp$ | 18,648 | 1.345     | 3.377    | -8.096   | 7.945  |
| $\Delta Slope10y2y$  | 18,648 | 0.00537   | 0.285    | -0.505   | 0.859  |
| $\Delta FSI$         | 18,648 | -0.0102   | 0.783    | -3.164   | 4.647  |
| $\Delta Treas$       | 18,648 | 8581      | 17261    | -12732   | 79842  |
| $\Delta Mbs$         | 18,648 | 22321     | 68252    | -77492   | 319545 |
| $\Delta Fedd10y$     | 18,648 | 32.60     | 153.7    | 0        | 1155   |
| $\Delta Indprod$     | 18,648 | 0.165     | 1.331    | -5.666   | 1.982  |
| $\Delta PCEPI$       | 18,648 | 0.453     | 0.412    | -1.596   | 1.079  |
| $\Delta S\&P500$     | 18,648 | 1.231     | 7.759    | -27.89   | 22.32  |
| $\Delta GS10y$       | 18,648 | -0.0352   | 0.330    | -0.840   | 0.713  |
| ResTreas             | 18,130 | -4.38e-05 | 11872    | -41965   | 61864  |
| ResMbs               | 18,130 | 5.67e-06  | 26833    | -77370   | 100715 |
| ResFedd10y           | 18,130 | 5.28e-08  | 49.67    | -155.8   | 155.5  |
| ResFedrate           | 18,130 | 5.99e-10  | 0.208    | -0.619   | 0.724  |

| Variable          | What does the variable capture   | Source   |
|-------------------|--|--|
| Z-score           | Bank's soundness   | Bloomberg and author's calculation                       |
| PD3m              | Bank's 3-months probability of default                                       | Bloomberg  |
| Liquidity         | Bank's liquidity : Loan to deposit ratio                                     | Bloomberg  |
| Loan growth       | Bank's Loan growth   | Bloomberg  |
| Tier1             | Bank's Tier1 ratio   | Bloomberg  |
| Size              | Bank's size: natural logarithm of its assets                                 | Bloomberg and author's calculation                       |
| Efficiency        | Bank's efficiency ratio : income-to-cost ratio                               | Bloomberg and author's calculation                       |
| ROA               | Bank's Return on Asset   | Bloomberg  |
| Business          | Bank's Corporate Loans to Household Loans ratio                              | Bloomberg and author's calculation                       |
| GDP growth        | Economic activity  | <a href="#">Federal reserve Bank of St Louis website</a> |
| <i>Fedrate</i>    | Fed effective interest rate  | <a href="#">Federal reserve Bank of St Louis website</a> |
| Taygap            | Fed Taylor gap: Fed rate- Taylor rule rate                                   | Author's calculation                                     |
| <i>Shiller hp</i> | Shiller national home price index  | <a href="#">Federal reserve Bank of St Louis website</a> |
| <i>Slope10y2y</i> | Slope of the yields curve  | <a href="#">Federal reserve Bank of St Louis website</a> |
| <i>FSI</i>        | St Louis Financial Stress index  | <a href="#">Federal reserve Bank of St Louis website</a> |
| <i>Treas</i>      | Fed 10-years Treasury securities holding                                     | <a href="#">Federal reserve Bank of St Louis website</a> |
| <i>Mbs</i>        | Fed 10-years mortgage backed securities holding                              | <a href="#">Federal reserve Bank of St Louis website</a> |
| <i>Fedd10y</i>    | Fed holding 10-year maturity Federal agency debt securities.                 | <a href="#">Federal reserve Bank of St Louis website</a> |
| <i>Indprod</i>    | Industrial production index  | <a href="#">Federal reserve Bank of St Louis website</a> |
| <i>PCEPI</i>      | Private Consumption Expenditure  | <a href="#">Federal reserve Bank of St Louis website</a> |
| <i>S&amp;P500</i> | S&P index  | <a href="#">Yale Department of Economics website</a>     |
| <i>GS10y</i>      | Sovereign yield on 10-year U.S. Treasuries                                   | <a href="#">Federal reserve Bank of St Louis website</a> |
| ResTreas          | Surprise on the Fed 10-years Treasury securities holding                     | <a href="#">Federal reserve Bank of St Louis website</a> |
| ResMbs            | Surprise on the Fed 10-years mortgage backed securities holding              | <a href="#">Federal reserve Bank of St Louis website</a> |
| ResFedd10y        | Surprise on the Fed holding 10-year maturity Federal agency debt securities. | <a href="#">Federal reserve Bank of St Louis website</a> |
| ResFedrate        | Surprise on the Fed effective interest rate                                  | <a href="#">Federal reserve Bank of St Louis website</a> |

Table 8 Correlation matrix of the variables used in the panel regression and VAR models  
(USA banks data, 2001Q2-2018Q4)

| (obs=18,130)                           |                                  |  |                                       |                                       |                                |                                  |                                |                                    |                                    |
|--|----------------------------------|--|---------------------------------------|---------------------------------------|--------------------------------|----------------------------------|--------------------------------|------------------------------------|------------------------------------|
|  | <b>Z</b>                         | <b>PD3m</b>                            | <b>Liquidity</b>                      | <b>Loan growth</b>                    | <b>Tier 1</b>                  | <b>Size</b>                      | <b>Efficiency</b>              | <b>ROA</b>                         | <b>Business</b>                    |
| <b>Z</b>                               | 1                                |  |                                       |                                       |                                |                                  |                                |                                    |                                    |
| <b>PD3m</b>                            | -0.0787                          | 1                                      |                                       |                                       |                                |                                  |                                |                                    |                                    |
| <b>Liquidity</b>                       | -0.192                           | 0.0667                                 | 1                                     |                                       |                                |                                  |                                |                                    |                                    |
| <b>Loan growth</b>                     | 0.0483                           | -0.0119                                | 0.113                                 | 1                                     |                                |                                  |                                |                                    |                                    |
| <b>Tier1 ratio</b>                     | 0.0870                           | -0.0659                                | -0.307                                | -0.126                                | 1                              |                                  |                                |                                    |                                    |
| <b>Size</b>                            | -0.00330                         | -0.0297                                | 0.104                                 | 0.0535                                | -0.164                         | 1                                |                                |                                    |                                    |
| <b>Efficiency</b>                      | -0.218                           | 0.0551                                 | -0.0473                               | -0.0968                               | 0.0151                         | -0.119                           | 1                              |                                    |                                    |
| <b>ROA</b>                             | 0.482                            | -0.0661                                | 0.0182                                | 0.197                                 | 0.00450                        | 0.0832                           | -0.298                         | 1                                  |                                    |
| <b>Business</b>                        | -0.0738                          | -0.00580                               | 0.0536                                | 0.0286                                | -0.0221                        | 0.0441                           | -0.0402                        | -0.00420                           | 1                                  |
| <b>GDP</b>                             | 0.0199                           | -0.0547                                | -0.0428                               | 0.0199                                | -0.0100                        | -0.0208                          | -0.0272                        | 0.0426                             | 0.00820                            |
| <b><math>\Delta Fedrate</math></b>     | 0.000300                         | -0.0214                                | -0.0464                               | -0.0119                               | 0.0374                         | 0.0526                           | -0.00240                       | 0.0118                             | 0.0293                             |
| <b><math>\Delta Shiller hp</math></b>  | 0.0310                           | -0.0614                                | -0.0824                               | 0.0267                                | 0.0185                         | -0.0144                          | -0.0436                        | 0.0702                             | 0.0148                             |
| <b><math>\Delta Slope10y2y</math></b>  | 0.00820                          | 0.0166                                 | 0.0498                                | 0.0257                                | -0.0385                        | -0.0316                          | -0.000100                      | 0.0132                             | -0.0263                            |
| <b><math>\Delta FSI</math></b>         | 0.00380                          | -0.0376                                | -0.000900                             | 0.00980                               | -0.0103                        | 0.00180                          | -0.00660                       | 0.00500                            | 0.00170                            |
| <b><math>\Delta Treas</math></b>       | -0.0796                          | 0.0130                                 | -0.0943                               | -0.124                                | 0.0832                         | 0.0117                           | 0.0495                         | -0.182                             | -0.000900                          |
| <b><math>\Delta Mbs</math></b>         | -0.0239                          | 0.0611                                 | 0.0246                                | -0.0588                               | 0.0260                         | 0.0111                           | 0.0329                         | -0.0462                            | -0.00340                           |
| <b><math>\Delta Fedd10y</math></b>     | -0.00890                         | 0.0661                                 | 0.0719                                | -0.0254                               | -0.0128                        | 0.00140                          | 0.00910                        | -0.0144                            | -0.0108                            |
| <b><math>\Delta Indprod</math></b>     | -0.0148                          | -0.0327                                | -0.0566                               | -0.00880                              | 0.0271                         | 0.00350                          | 0.00190                        | -0.0357                            | 0.00340                            |
| <b><math>\Delta PCEPI</math></b>       | 0.0116                           | -0.0185                                | 0.0148                                | 0.0107                                | -0.0443                        | -0.0290                          | -0.0197                        | 0.0193                             | -0.00840                           |
| <b><math>\Delta S\&amp;P500</math></b> | -0.0202                          | 0.0106                                 | -0.0280                               | -0.0320                               | 0.0353                         | 0.0269                           | 0.0222                         | -0.0399                            | 0.00720                            |
| <b><math>\Delta GS10y</math></b>       | 0.0120                           | -0.0139                                | -0.0151                               | 0.00410                               | 0.00820                        | 0.0281                           | -0.00470                       | 0.0315                             | 0.0116                             |
| <b>ResTreas</b>                        | -0.0386                          | 0.0166                                 | -0.0394                               | -0.0497                               | 0.0328                         | 0.00870                          | 0.0235                         | -0.0900                            | -0.00420                           |
| <b>ResMbs</b>                          | 0.0143                           | -0.00150                               | 0.0205                                | -0.00740                              | -0.0310                        | -0.0132                          | -0.0144                        | 0.0332                             | 0.00180                            |
| <b>ResFedd10y</b>                      | -0.0225                          | 0.0488                                 | 0.0315                                | -0.0211                               | -0.00150                       | 0.00410                          | 0.0221                         | -0.0529                            | -0.00780                           |
| <b>ResFedrate</b>                      | 0.0112                           | -0.00430                               | -0.00350                              | -0.0111                               | -0.0127                        | -0.00750                         | -0.0114                        | 0.0260                             | 0.0127                             |
|  | <b>GDP</b>                       | <b><math>\Delta Fedrate</math></b>     | <b><math>\Delta Shiller hp</math></b> | <b><math>\Delta Slope10y2y</math></b> | <b><math>\Delta FSI</math></b> | <b><math>\Delta Treas</math></b> | <b><math>\Delta Mbs</math></b> | <b><math>\Delta Fedd10y</math></b> | <b><math>\Delta Indprod</math></b> |
| <b>GDP</b>                             | 1                                |  |                                       |                                       |                                |                                  |                                |                                    |                                    |
| <b><math>\Delta Fedrate</math></b>     | 0.529                            | 1                                      |                                       |                                       |                                |                                  |                                |                                    |                                    |
| <b><math>\Delta Shiller hp</math></b>  | 0.524                            | 0.508                                  | 1                                     |                                       |                                |                                  |                                |                                    |                                    |
| <b><math>\Delta Slope10y2y</math></b>  | -0.351                           | -0.593                                 | -0.346                                | 1                                     |                                |                                  |                                |                                    |                                    |
| <b><math>\Delta FSI</math></b>         | -0.166                           | -0.289                                 | -0.112                                | 0.154                                 | 1                              |                                  |                                |                                    |                                    |
| <b><math>\Delta Treas</math></b>       | -0.0411                          | -0.0346                                | 0.0759                                | 0.138                                 | -0.0978                        | 1                                |                                |                                    |                                    |
| <b><math>\Delta Mbs</math></b>         | -0.165                           | -0.00620                               | 0.000500                              | 0.248                                 | -0.303                         | 0.286                            | 1                              |                                    |                                    |
| <b><math>\Delta Fedd10y</math></b>     | -0.158                           | 0.00470                                | -0.0771                               | 0.187                                 | -0.295                         | 0.0721                           | 0.628                          | 1                                  |                                    |
| <b><math>\Delta Indprod</math></b>     | 0.710                            | 0.462                                  | 0.393                                 | -0.242                                | -0.0156                        | 0.154                            | 0.000200                       | 0.0685                             | 1                                  |
| <b><math>\Delta PCEPI</math></b>       | 0.583                            | 0.328                                  | 0.225                                 | 0.00830                               | -0.271                         | 0.0687                           | -0.0929                        | 0.0668                             | 0.489                              |
| <b><math>\Delta S\&amp;P500</math></b> | 0.417                            | 0.325                                  | 0.194                                 | -0.0647                               | -0.500                         | 0.123                            | 0.312                          | 0.294                              | 0.314                              |
| <b><math>\Delta GS10y</math></b>       | 0.294                            | 0.277                                  | 0.229                                 | 0.247                                 | -0.268                         | 0.0665                           | 0.210                          | 0.169                              | 0.155                              |
| <b>ResTreas</b>                        | -0.161                           | -0.0992                                | -0.0557                               | 0.148                                 | 0.0121                         | 0.681                            | 0.0653                         | -0.0440                            | 0.0579                             |
| <b>ResMbs</b>                          | 0.0918                           | 0.0662                                 | 0.0800                                | 0.134                                 | -0.136                         | 0.114                            | 0.388                          | -0.106                             | -0.00500                           |
| <b>ResFedd10y</b>                      | 0.0269                           | -0.0289                                | -0.294                                | 0.00490                               | -0.167                         | -0.0939                          | -0.129                         | 0.319                              | 0.0639                             |
| <b>ResFedrate</b>                      | 0.274                            | 0.529                                  | 0.263                                 | -0.504                                | -0.261                         | -0.127                           | 0.0486                         | -0.0174                            | 0.0464                             |
|  | <b><math>\Delta PCEPI</math></b> | <b><math>\Delta S\&amp;P500</math></b> | <b><math>\Delta GS10y</math></b>      | <b>ResTreas</b>                       | <b>ResMbs</b>                  | <b>ResFedd10y</b>                | <b>ResFedrate</b>              |                                    |                                    |
| <b><math>\Delta PCEPI</math></b>       | 1                                |  |                                       |                                       |                                |                                  |                                |                                    |                                    |
| <b><math>\Delta S\&amp;P500</math></b> | 0.283                            | 1                                      |                                       |                                       |                                |                                  |                                |                                    |                                    |
| <b><math>\Delta GS10y</math></b>       | 0.349                            | 0.409                                  | 1                                     |                                       |                                |                                  |                                |                                    |                                    |
| <b>ResTreas</b>                        | 0.0577                           | -0.151                                 | -0.0549                               | 1                                     |                                |                                  |                                |                                    |                                    |
| <b>ResMbs</b>                          | 0.183                            | 0.140                                  | 0.285                                 | 0.168                                 | 1                              |                                  |                                |                                    |                                    |
| <b>ResFedd10y</b>                      | 0.143                            | 0.166                                  | -0.0476                               | -0.138                                | -0.333                         | 1                                |                                |                                    |                                    |
| <b>ResFedrate</b>                      | 0.299                            | 0.0870                                 | 0.248                                 | -0.187                                | 0.125                          | -0.0546                          | 1                              |                                    |                                    |

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