Bank Stock Returns and Monetary Policy Surprises: Before and After the Financial Crisis

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ABSTRACT

Using daily bank stock data and quarterly balance sheet data, we estimate the reaction of bank stock returns and maturity mismatches to surprise changes in the federal funds rate and the slope of the yield curve on FOMC dates, before and after the financial crisis of 2008. We find that the reaction of U.S. bank holding companies' stock returns to unexpected increases in the federal funds rate and the slope of the yield curve has reversed after the financial crisis, being a positive reaction in the post-crisis period. The reaction of bank stock returns to interest rate changes appears to be amplified for larger banks both before and after the financial crisis. Our results also indicate that banks' maturity mismatches increase following surprise increases in the interest rate in the post-crisis period, which is also a reversed effect. The results in this paper support the notion of a reversal interest rate in the United States.

Keywords: Monetary Policy, FOMC Announcements, Interest Rate Surprises, Maturity Mismatch

JEL classification: E43, E44, E52, G21

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I. Introduction

Banking is an industry often considered to be fundamentally different from others. A defining function of banks is maturity transformation, borrowing short term via deposits and lending over a longer term. This function plays an important role in the macroeconomy as a whole, having effects on savings and the supply of credit. According to conventional wisdom, this subjects banks to interest rate risk.

This in turn should mean that monetary policy can incentivize banks to take certain actions through the manipulation of interest rates. Due to the different balance sheet composition of banks, the effects of interest rates on bank stock prices are different than for non-financial firms. There has been extensive research investigating banks' exposure to interest rate risk. However, some of the results in the literature have been contradictory and have shown variation over time.

The federal funds rate (FFR) has been the key policy instrument in the US over a long time (Bernanke and Mihov, 1998), which makes it a useful tool for measuring the effect of monetary policy on banks. The FFR reached the zero lower bound in December 2008 and interest rates after the financial crisis have been lower than they have ever been. Considering changes to banking regulations, the low interest rate policy and the fundamentally different market environment, it is possible that the effect of monetary policy on banks has changed after the financial crisis. The current state of the effects of monetary policy shocks on U.S bank stocks is an unexplored area of research. It is important to hold an updated view on the effect of monetary policy on banks as it affects the lending behavior, profitability and stability of banks, which transmits the effect of monetary policy into the real economy (Van den Heuvel, 2007).

This paper compares the effect of conventional monetary policy shocks prompted by FOMC announcements made by the Federal Reserve (Fed) on U.S. bank holding companies' (BHC) stock returns before and after the financial crisis of 2008. This is done by replicating, with modifications, the study by English et al. (2018) *Interest Rate Risk and Bank Equity Valuations* and extending it with data from 2012–2019, referred to in this paper as the post-crisis period. As monetary policy actions affect banks through several channels, stock prices can be a useful measure of the overall effect on banks. This paper also investigates how U.S. banks have adjusted to the low interest rate environment by analyzing the reactions of their maturity mismatches to monetary policy shocks before and after the financial crisis.

Recent results by Bailey and Matyáš (2019) show an increased sensitivity of banks' equity valuations to interest rate risk after the financial crisis, with the relation between banks' stock returns and the slope of the yield curve inverting between the time periods. After the financial crisis, a positive shift in the yield curve improved bank stock returns and negative shifts in the yield curve have led to worse bank stock returns. This, in combination with conflicting results in previous literature over time, including English et al. (2018) and Flannery and James (1984), opens for further investigation on the current relationship between monetary policy, bank characteristics and stock returns after the financial crisis.

Our contribution to the literature is threefold. Primarily, we extend the study of English et al. by including the years 2012–2019, addressing the question if the effect of conventional monetary policy on U.S. bank stock returns has changed after the financial crisis. Secondly, we determine if the results in English et al.'s original study are replicable using daily stock price data; those researchers used high frequency trading data to come to their conclusions. Finally, we provide an updated view on the relationship between banks' maturity mismatch and interest rates, and compare this effect before and after the financial crisis.

Based on what is mentioned above, the aim of this paper is to answer the following questions:

How do monetary policy shocks impact bank holding companies' stock returns and does this vary with certain bank characteristics? Have these relationships changed in the aftermath of the financial crisis?

For the purposes of answering these questions, a monetary policy shock is defined as an unexpected change in the federal funds rate, measured using fed funds futures contracts, following Federal Open Market Committee (FOMC) meetings. We employ the same method used in the study by English et al. (2018) and the method of Kuttner (2001). This method allows us to separate changes in the FFR into expected and unexpected components, capturing the exogenous effect of the monetary policy actions. The method used by English et al. (2018) is also used to measure the unexpected change in the slope of the yield curve, as determined by U.S. Treasury yields. The characteristics of individual banks can be determined through the use of regulatory filings in FR Y-9C reports and call reports.

With this data, we analyze and compare two distinct time periods. The first time period is 1997–2007 and the second period is 2012–2019. For each period we analyze the stock performance of our sample of BHCs on the FOMC announcement days, 84 days in the first period, 65 days in the second period, and compare this to the individual banks' characteristics. This analysis is done using Ordinary Least Square (OLS) regressions.

We begin our study by replicating the baseline regression present in the study by English et al. (2018) of stock returns and monetary policy shocks from 1997–2007. Our results are largely similar to those in the original study, meaning that an unexpected rise in interest rates had a negative effect on bank stock returns. An unexpected increase in the slope of the yield curve also had a negative effect. The difference in results was with the explanatory power of the coefficients. Since we use daily returns and the original study used high frequency trading data, explanatory power (measured by R-squared) was lost relative to English et al. One quarter to one third of the original effect from the monetary policy shocks remained over a daily horizon, compared to the hourly horizon in English et al.'s study.

Running a similar regression for the post-crisis period, 2012–2019, we find that the relationship between unexpected increases in the federal funds rate and the slope yield curve and bank stock returns inverted to a positive relationship. The relationships have also become stronger, meaning bank stocks react more strongly to conventional monetary policy shocks in the post-crisis period.

After these baseline regressions, we add individual bank characteristics to the regressions for both periods. We find indications that daily stock return data might not be suitable for analyzing the way bank characteristics interact with these stock returns during monetary policy shocks, as effects become increasingly difficult to isolate. Not all statistically significant relationships in the pre-crisis version of this regression corresponded to results in English et al. (2018).

Nevertheless, the coefficients in those regressions imply that large banks with larger dividend yields and greater shares of deposit financing were more affected by monetary policy shocks, both in the pre-crisis and post-crisis periods. Meanwhile, banks with larger loan to asset ratios and greater maturity mismatches seemed to be less affected by these shocks in both periods.

The final regression analyzes the effect of monetary policy shocks on banks' maturity mismatches and also shows a reversed effect. Surprise increases in the level of interest rate would cause banks' maturity mismatches to decrease in the pre-crisis period, but in the post-crisis period maturity mismatches would increase with positive shocks to the FFR. The reversal of the effect of expansionary monetary policy on banks' maturity mismatches is in line with the notion of a reversal interest rate (Brunnermeier and Koby, 2019).

The rest of this paper is organized as follows: Section II, reviews the related literature; Section III describes the methodology; Section IV describes the data; Section V presents the empirical results; Section VI discusses the empirical results; and Section VII concludes the paper.

II. Literature review

The reaction of banks stock returns to interest rate changes has been covered in various ways in the literature before. Flanery and James (1984) concluded that bank stocks react negatively to rises in long term rates, and that banks holding a larger maturity mismatch are to a greater extent exposed to interest rate risk (Flannery and James 1984).

English et. al.'s 2018 study *Interest Rate Risk and Bank Equity Valuations*, the main inspiration for this paper, evaluates the reaction of bank stock prices to announcements by the Federal Open Market Committee (FOMC) between 1997 and 2007 and how this reaction varies with different bank characteristics. Their research came to the conclusion that bank equity returns reacted negatively to increases in interest rates during the target period, both from change in the level of interest rate and slope of the yield curve. They observed that the reaction is larger for banks that are more reliant on core deposits and reduced for banks with large maturity mismatches, defined as the difference between the maturities of assets and liabilities on the balance sheet. This contradicts Flannery and James (1984).

The mitigating effect of a larger maturity mismatch implies that banks benefit from a steep yield curve, considering their role as maturity transformers, taking on shorter term liabilities and longer term assets. However, it defies conventional wisdom in that lower interest rates increase profitability. A rise in market rates is normally expected to boost bank profitability because banks fund a portion of their interest earning assets with non interest bearing liabilities. Different to English et al. (2018), we extend our dataset to include a period after the financial crisis, covering the years 2012 to 2019, to identify changes over time.

While English et. al.'s relationship holds before the financial crisis of 2008, according to Bailey and Matyáš (2019) in its aftermath the relationship has reversed. In other words, after the financial crisis positive shifts in the yield curve improve bank stock returns, and negative shifts in the yield curve worsen banks' stock returns. Banks also appear to have become increasingly sensitive to interest rate risk. Our method differs from that of Bailey and Matyáš primarily in our identification of the unexpected change in slope of the yield curve and also including the level effect of changes in the interest rate, as well as how these reactions vary with certain bank characteristics.

Ampudia and Van den Heuvel (2018) investigate similar research questions as English et al. (2018). They investigate the effects of monetary policy on the equity values of European banks, as well as exploring how the effect varies with certain bank characteristics. They find that over the whole sample period between 1999–2016 a surprise decrease of the interest rate of 25 basis points increases equity return by 1% on average. However, they note that this relationship has switched after the financial crisis, as well as having become stronger. Their findings thus suggest that the effect of monetary policy on banks is non-monotonic. Our study is primarily different from that of Ampudia and Van den Heuvel as we investigate the difference in the effect of conventional monetary policy over time in a U.S. setting.

Brunnermeier and Koby (2019) make similar model based predictions as Bailey and Matyáš. In their study, *The Reversal Interest Rate*, they show that under certain conditions there exists a reversal interest rate, which is the rate at which expansionary monetary policy actions have a reversed effect than intended, and become contractionary to bank lending. Unlike Brunnermeier and Koby, our study empirically test the effect of the federal funds rate on bank stock returns and its impact on maturity mismatches.

Di Tella and Kurlat (2017) find that maturity mismatches tend to increase in times of low interest rates. Drechsler et al. (2018) postulate that banks' business of maturity transformation does not expose them to significant interest rate risk, but on the contrary, offsets it. Drechsler et al. note that the aggregate net interest margin (NIM) of the banking industry has been stable between 2.2% and 3.7% for over 60 years, despite interest rates fluctuating substantially over the same time period. Banks are able to offset interest rate risk by matching the sensitivity of their interest expenses to their interest income by paying deposit by holding an optimal maturity mismatch.

Our method of identifying the effect of the interest rate on banks' maturity mismatches differs in the sense that we investigate how banks' maturity mismatches change in reaction to unexpected changes in the level of the interest rate. We also separate our data set into pre-crises and post-crisis time periods to identify differences over time.

III. Methodology

Monetary policy shocks

A monetary policy shock is defined as an unexpected change in monetary policy. In the context of our investigation into the U.S. banking sector, it refers to unanticipated changes in the Federal Reserve's target interest rate on days of FOMC announcements.

By the method used in English et al. (2018), shocks are quantified in two ways. First, we determine the expected change in the federal funds rate indicated by fed funds futures. Then we calculate the difference between the expected and the actual change in the interest rate, resulting in a variable we call the "level surprise", i.e. the unexpected change to the level of the federal funds rate. These calculations can be specified as:

$$\Delta ff_t - \Delta ff_t^e = \Delta ff_t^u$$

Where Δff_t refers to the actual change in the FFR, Δff_t^e is the expected change, and Δff_t^u is the unexpected change, referred to as the level surpris. This relationship can thus also be specified as: $\Delta ff_t = \Delta ff_t^e + \Delta ff_t^u$.

As our fed funds futures data is calendar adjusted, we do not apply the calendar adjustment method of Kuttner (2001), but rather the simpler specification presented above.

Second, we determine the surprise change in the slope of the yield curve on days of FOMC announcements, referred to as the slope surprise. The slope surprise is also constructed following the method of English et al. (2018), and calculated by subtracting the change in the *m*-year Treasury yield by the level surprise. It can be specified as follows:

$$\Delta y_t^m - \Delta ff_t^u$$

Where Δy_t^m is the daily change in the *m*-year Treasury yield and Δff_t^u is the unexpected change in the FFR as defined above. We apply this to the 2-year, 5-year and 10-year Treasury yields.

This method allows us to measure the exogenous effect of monetary policy changes, as we separate the expected and unexpected variation from each other. Following the efficient market hypothesis, bank stock returns should only react to the unexpected change as all information and expectations held beforehand should already have been incorporated into the stock prices, but we keep the expected change in our baseline regression as a control variable.

For descriptive statistics and graphic representations of these monetary policy shocks are present in the appendix.

Baseline regression - Interest rate surprises and bank stock returns

To test the effect of interest rate changes on bank stock returns, we apply the same baseline OLS regression as English et al. (2018) in Eq. 1:

$$R_{it} = \beta_0 + \beta_1 \Delta ff_t^e + \beta_2 \Delta ff_t^u + \beta_3 (\Delta y_t^m - \Delta ff_t^u) + \varepsilon_{it} \quad (1)$$

where R_{it} is bank *i*'s simple intraday return factor over the window of policy date *t*. Our method is different from that of English et al. only in that we use daily data, where the shock is calculated using fed funds futures and bond prices the day before and the day after FOMC meetings. This is due to a lack of high frequency data (see Data description).

As in the study by English et al., our data is made up of irregularly-spaced, non-adjacent intraday stock returns, which leads us to assume that the error term ε_{it} is almost certainly serially uncorrelated. However, as noted by English et al., since we use a set of specific common shocks to bank stock returns, the baseline regression can exhibit a complex pattern of cross-sectional dependence. To ensure that our inference is robust to the presence of cross-sectional dependence in the error term we report standard errors clustered across time.

The focus of this paper is conventional monetary policy shocks that affect the federal funds rate and the slope of the yield curve. However, not considering unconventional monetary policy announcements, in the post-crisis period, could prove to be problematic, as this economic news is often announced at the same time as the conventional monetary policy on FOMC dates. This could interfere with our result as it might be captured in banks' same day stock returns. The Federal Reserve released news relating to quantitative easing (QE) in conjunction with 14 of the 65 FOMC announcements in the post-crisis period. In order to isolate the effect of the conventional monetary policy shocks, we create a dummy control variable for FOMC meetings during which the Federal Reserve released new information regarding QE in their statement, during a press conference or in a press release on the same day. In this way, we have some way of determining and isolating the effect of the conventional monetary policy shocks.

Thus, the baseline regression in the post-crisis period includes a dummy control variable for QE announcements.

Bank stock return and bank characteristics

After running our baseline regression, we turn to investigate how the reaction of bank stock returns to monetary policy surprises varies with certain bank characteristics. The regression is specified in Eq. 2:

$$R_{it} = \beta_0 + \beta_1 \Delta ff_t^u + \beta_2 (\Delta y_t^m - \Delta ff_t^u)$$
$$+ \gamma_1 [X_{it} * \Delta ff_t^u] + \gamma_2 [X_{it} * (\Delta y_t^m - \Delta ff_t^u)] + \eta_i + \varepsilon_{it} \quad (2)$$

where R_{it} is bank *i*'s simple intraday return factor over the window of policy date *t*, Δff_t^u is the level surprise, $(\Delta y_t^m - \Delta ff_t^u)$ is the *m*-year slope surprise, X_{it} is a vector of certain bank characteristics interacted with both the level surprise and the slope surprise. The interaction allows the reaction of bank stock returns to the level and slope surprise to depend linearly on the bank characteristics. Eq. 2 also includes a bank specific fixed effect, denoted by η_i, to control for other time invariant bank characteristics.

For the choice of bank characteristics we follow the method of English et al. (2018), including the same characteristics as in their study that a priori would be thought of as having an effect on the reaction of bank stock returns to changes in the interest rate. These include: maturity mismatch, other assets and liabilities, deposit ratio[1], market leverage, loans to assets ratio and bank size. In our paper, we also add the variable dividend yield to the bank characteristics. We add dividend yield to our specification because it, a priori, it would be thought that as a bank pays out/announces dividends on its common stock, this will have a negative effect on its equity capital in the near future, limiting its possibility to act on the policy action through, for example, its loan origination and deposit supply. Further guidance on the calculation of bank characteristics is presented in the appendix.

In Eq. 2, the bank characteristic variables are lagged to represent data from the closest prior quarter to the FOMC date following the methodology of English et al. This is because, to be able to capture the effect of certain bank characteristics, those characteristics must have been available at the time of the FOMC announcement. We do, however, use the subscript *t* in the specification for simplicity.

Similar to our baseline regression, Eq. 2 includes a QE dummy control variable for the post-crisis period.

Maturity mismatch

We calculate the maturity mismatch following the granular method of English et al. (2018), where we aggregate call report data filed by U.S. commercial banks to BHC level using relationship data from the FFIEC. The maturity mismatch is the difference between the

[1] Including non-demand savings deposits and demand deposits

weighted-average repricing/maturity period of assets and liabilities respectively, measured in months. It can be specified as:

$$GAP_{it} = \Xi^{A}_{it} - \Xi^{L}_{it}$$

The "true" maturity period of a bank's assets is as follows:

$$\Xi^{A}_{it} = \frac{(\Sigma_j\, m^{j}_{A} A^{j}_{it}) + m^{OTH}_{A} A^{OTH}_{it}}{A^{IE}_{it}}$$

Where A^{j}_{it} is the dollar amount of asset item j reported by bank i in quarter t, and m^{j}_{A} is the average repricing period for asset item j. Total earning assets, A^{IE}_{it}, is the denominator. A^{IE}_{it} is the sum of the items included in item number 3402 (quarterly average of earning assets) in the Fed micro data reference manual (see appendix). Other assets, A^{OTH}_{it} are assets for which there is no repricing/maturity information available. It is measured as:

$$A^{OTH}_{it} = A^{IE}_{it} - \Sigma_j\, A^{J}_{it}$$

The "true" maturity period of a bank's liabilities is as follows:

$$\Xi^{L}_{it} = \frac{(\Sigma_j\, m^{j}_{L} L^{j}_{it}) + m^{OTH}_{L} L^{OTH}_{it}}{L^{Total}_{it}}$$

Where L^{j}_{it} is the dollar amount of liability item j reported by bank i in quarter t, and m^{j}_{l} is the average repricing period for liability item j. Total liabilities is the denominator. Other liabilities, L^{OTH}_{it}, for which there is no repricing/maturity information, is measured as:

$$L^{OTH}_{it} = L^{Total}_{it} - \Sigma_j\, L^{J}_{it}$$

Although the "true" maturity mismatch is presented above, the measured maturity mismatch used in our regressions is:

$$GAP^{*}_{it} = \sum_j m^{j}_{A} \frac{A^{j}_{it}}{A^{IE}_{it}} - \sum_j m^{j}_{L} \frac{L^{j}_{it}}{L_{it}}$$

As we follow the methodology of English et al. we have left out other assets and liabilities from our estimations. This alternate measure is used because there is no reliable way to estimate the true repricing/maturity time of other assets and liabilities.

Maturity mismatch and interest rates

Our third regression is presented in Eq. 3:

$$\Delta GAP_{iq} = \beta_0 + \beta_1 \Delta ff^{e}_{q} + \beta_2 \Delta ff^{u}_{q} + \beta_3 E_{iq} + \beta_4 L_{iq} + \eta_i + \varepsilon_{iq} \quad (3)$$

Where the dependent variable, ΔGAP_{iq}, is a simple measure of the quarterly change in bank i's maturity mismatch (in months), defined as:

$$\Delta GAP_{iq} = GAP^*_{iq} - GAP^*_{iq-1}$$

In Eq. 3, we use the closest following balance sheet date to our FOMC dates, to capture the effect of the monetary policy actions. As we use quarterly data on the left hand side of the regression in Eq. 3, Δff^e_q and Δff^u_q represent the total expected and unexpected changes in the federal funds rate within a quarter, otherwise following the same methodology as above. We use the notation q in Eq. 3 to indicate the use of quarterly data.

We use lagged versions of banks' equity ratio and liquidity ratio as control variables in Eq. 3, as these variables have been used as control variables in the literature before for the sensitivity of banks' lending to the interest rate (Kashyap and Stein, 1994; Gomez et al., 2016). The equity ratio is also applicable as a control, as banks' deposit supply is dependent on their net worth. We also use the subscript q for the control variables for simplicity. Further guidance on the calculation of the control variables is presented in the appendix.

We include a bank specific fixed effect, denoted by η_i, in Eq. 3 to control for other unobserved time invariant bank characteristics. We cluster the standard errors on BHC level.

Bank holding companies

We base our sample of U.S. BHCs on the same 355 banks studied by English et al., who kindly shared this data with us, to make our results more comparable to their original study. Our data set does, however, differ somewhat from that of English et al. due to a lack of readily available merger adjusted data. In the pre-crisis period our sample includes 330 BHCs, and in the post-crisis period it includes 174 BHCs.

Time frame

In order to test for difference between time periods, we split up our data set in two distinct time periods; before and after the financial crisis:

i) Pre-crisis period: July 2nd 1997 - June 28th 2007

ii) Post-crisis period: January 25th 2012 - December 11th 2019

Our time frame begins on July 2nd 1997 as repricing data of assets and liabilities used to calculate the maturity mismatch became available in call reports around this time. Our time period of interest ends on December 11th 2019 as it is the latest quarter with available call report data. We exclude the period between Q3 2007 and Q4 2011 from our sample, based on the method of English et al. (2018) and Bailey and Matyáš (2019), due to the extraordinary circumstances during that time, avoiding including effects of the uncommon measures taken by the Federal Reserve at the same time, as well as due to that monetary policy can be influenced by other factors other than the economic environment (Cieslak et al. 2019). While the financial crisis and recession in the United States technically only lasted until mid-2009, several consequences of the crisis did not manifest until later, including the passing of the

Dodd-Frank Wall Street Reform and Consumer Protection Act in mid 2010, subsequent edits to the same law, new waves of quantitative easing and continued turbulence in foreign markets (disproportionately affecting U.S. bank stocks with more foreign exposure). These factors have led us to define our post-crisis period as 2012–2019.

IV. Data description

We gather bank stock data from the Center for Research in Security Prices (CRSP) database, accessible through Wharton Research Data Services (WRDS). We collect data on stocks' daily return for our banks of interest on the days of FOMC announcements in both time periods. Since 1994, the Fed makes FOMC announcements at 2.15 PM Est., meaning bank stock prices will have had time to incorporate new information from FOMC announcements within the same day.

For bank balance sheet data we use regulatory data filed by bank holding companies in their FR Y-9C reports. This data is gathered from the Bank Regulatory database, bank holding companies section, accessible to us through WRDS.

To calculate banks' maturity mismatches, we use regulatory call report data filed by commercial banks in the United States. Call report data is extracted from the Federal Financial Institutions Examination Council (FFIEC) database on a quarterly basis for the time periods: Q1 2001 to Q2 2007 and Q1 2012 to Q4 2019. Due to call report data only being available from the FFIEC website from Q1 2001 and onwards, we gather call report data for the period Q3 1997 to Q4 2000 from the RCON-series in the aforementioned Bank Regulatory database. Since call reports provide data at the commercial bank level, they must be aggregated to the BHC level. To aggregate call report data to the BHC level, we use relationship data from the FFIEC National Information Center to identify commercial banks' with their respective BHC.

Data on FOMC announcements was retrieved from the website of the Federal Reserve and the FRASER library provided by the St. Louis Fed. We collect data on the change in the federal funds rate from the FOMC announcement transcripts for the periods: Q3 1997 to Q2 2007 and Q1 2012 to Q4 2019. From 1997–2007 there were 86 FOMC announcements, that became 84 when the two announcements in the immediate aftermath of the september 11th attacks were excluded, following the method of English et al. (2018). Between 2012 and 2019, 65 FOMC announcements were made. In the first time period, there were three unscheduled intermeeting FOMC announcements and in the second period there was one such announcement. Data on the FOMC dates with announcements including information regarding QE is also gathered from the website of the Federal Reserve. Our sample includes 14 FOMC announcements that include information regarding QE.

We collect calendar weighted adjusted data on CBOT-30 federal funds futures from data service provider MacroTrends for the day before and after the FOMC announcements. This is because it takes one day to change the actual federal funds rate and thus for the effect to show up in the data to its full extent.

Daily Treasury Yield Curve Rates for Treasuries with maturities of 2, 5, and 10-years are collected from the U.S. Department of the Treasury for the day before and the day of the FOMC announcement. Since 1994 the Federal Reserve makes FOMC announcements at 2.15 PM Est., while Treasury data is obtained by the Federal Reserve Bank of New York at or near 3:30 PM Est. each trading day. This means that the information from the FOMC announcement will generally have had time to be incorporated into the yield rates within the same day.

We deviate from our described methodology only once for the unscheduled announcement on the 15th of October 1998, as this announcement was made at 3.15 PM Est., which was after the futures market in Chicago had closed. We adjust our data in regards to this by using the data on the announcement day and the day after for this date.

V. Empirical results

Table I a)

Interest rate surprises and bank stock returns 1997–2007

Table I a) reports the results from the OLS regression:

$$R_{it} = \beta_0 + \beta_1 \Delta ff_t^e + \beta_2 \Delta ff_t^u + \beta_3 (\Delta y_t^m - \Delta ff_t^u) + \varepsilon_{it}$$

where R_{it} is bank *i*'s simple intraday return factor over the window of policy date *t*, Δff_t^e is the expected changes in the level of interest rate, Δff_t^u is the level surprise and $(\Delta y_t^m - \Delta ff_t^u)$ is the *m*-year slope surprise. Standard errors are clustered across time, following the method of English et al. (2018). The columns refer to different maturity horizons (*m*) for the slope surprise, including the 2-year, 5-year and 10-year Treasury yields respectively. Data regards the pre-crisis period, 1997Q3–2007Q2.

Table I a)

VARIABLES	(1) *m* = 2-year	(2) *m* = 5-year	(3) *m* = 10-year
Expected change: Δff^e	**0.006***	0.005	0.005
	(0.003)	(0.003)	(0.003)
Level surprise: Δff^u	**-0.048******	**-0.045******	**-0.039***
	(0.015)	**(0.016)**	**(0.020)**
Slope surprise: $(\Delta y^m - \Delta ff^u)$	**-0.023***	-0.016	-0.009
	(0.012)	(0.012)	(0.015)
Constant	**0.002******	**0.002******	**0.002******
	(0.001)	**(0.001)**	**(0.001)**
Observations	18,118	18,118	18,118
Adjusted R-squared	0.021	0.018	0.016

Note: Sample period: 84 policy actions between 7/2/1997 and 6/28/2007; No. of banks = 330. Standard errors clustered across time are reported in parentheses. (***, **, *) indicate significance at the 1%, 5%, 10% level. Significant coefficients are in bold.

As reported on the first line of the table, the expected change variable is only significant for the 2-year slope surprise, but not for the 5 and 10-year slope surprises. It can also be noted that the coefficients for the expected change variable are not economically large. This result is in line with our expectations based on the efficient market hypothesis, as well as the results in the original study by English et al. (2018).

In contrast, as can be seen on line two, the level surprise is statistically significant for all yield maturities. This effect is economically large, as the average effect of the level surprise, not taking the slope effect into account, for an increase of the federal funds rate of 25 basis points entailed a negative effect on daily bank stock returns of between 1% and 1.2%, depending on the Treasury yield.

The slope surprise is also statistically significant, but only for the 2-year Treasury yield. Meaning, bank stocks would react negatively to a slope surprise of 25 basis points in the 2-year Treasury yield, on average, by a factor of 0.6%.

These results are in the same direction as those in the study by English et al., however, with weaker effect and with roughly one quarter of the explanatory power, measured by R-squared. In the study by English et al., the R-squared was between 0.099 and 0.103. This is relatively unsurprising, as we use daily returns, that makes the effect of FOMC announcements more difficult to isolate, compared to using high frequency data that was used in the original study.

Table I b)

Interest rate surprises and bank stock returns 2012–2019

Table I b) reports the results for the OLS regression:

$$R_{it} = \beta_0 + \beta_1 \Delta ff_t^e + \beta_2 \Delta ff_t^u + \beta_3 (\Delta y_t^m - \Delta ff_t^u) + \beta_4 QE_t + \varepsilon_{it}$$

where R_{it} is bank i's simple intraday return factor over the window of policy date t, Δff_t^e is the expected changes in the level of interest rate, Δff_t^u is the level surprise, $(\Delta y_t^m - \Delta ff_t^u)$ is the m-year slope surprise and QE_t is a dummy control variable for QE announcements. Standard errors are clustered across time, following the method of English et al. (2018). The columns refer to different maturity horizons (m) for the slope surprise, including the 2-year, 5-year and 10-year Treasury yields respectively. Data regards the post-crisis period, 2012Q1–2019Q4.

Table I b)

VARIABLES	(1) m = 2-year	(2) m = 5-year	(3) m = 10-year
Expected change: Δff^e	-0.017	**-0.019***	-0.014
	(0.011)	**(0.010)**	(0.010)
Level surprise: Δff^u	**0.142****	**0.123***	**0.120***
	(0.061)	**(0.073)**	**(0.063)**
Slope surprise: $(\Delta y^m - \Delta ff^u)$	**0.083*****	0.012	**0.078*****
	(0.029)	(0.013)	**(0.027)**
QE (control)	-0.005	-0.005	-0.004
	(0.004)	(0.004)	(0.004)
Constant	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
Observations	8,383	8,383	8,383
Adjusted R-squared	0.060	0.027	0.070

Note: Sample period: 65 policy actions between 1/25/2012 and 12/11/2019; No. of banks = 174. Standard errors clustered across time are reported in parentheses. (***, **, *) indicate significance at the 1%, 5%, 10% level. Significant coefficients are in bold.

The expected change variable reported on the first line in table I b) is only significant for the 5-year slope surprise, but not for the 2- and 10-year slope surprises. It can also be noted that the coefficients are substantially smaller than those of the level surprise reported on line two. These results are similar to those reported in table 1 a) and in line with our expectations that banks stock returns should only react to new information, according to the efficient market hypothesis.

In the post-crisis period, the level surprise is still statistically significant, however at a lower significance level compared to the pre-crisis period, for all yield maturities. The effect of the level surprise has inverted, now being positive. Meaning that, on average, an unexpected rise in the level of the interest rate has a positive effect on banks stock returns on FOMC dates. The effect of the level surprise has also become stronger in the post-crisis period. The average effect of the level surprise, not taking the slope effect into account, of 25 basis points entails a positive reaction of daily bank stock returns of between 3% and 3.5%, depending on the Treasury yield.

The slope surprise for the 2 and 10-year Treasury yields are also statistically significant, at a higher significance level in the post-crisis period. The coefficients for the slope surprise are also positive, meaning that an increase in the slope of the yield curve is associated with an increase in bank stock returns on FOMC dates. It can also be noted that the coefficients are larger for the 2-year and 10-year maturities, compared to in the pre-crisis period. In the post-crisis period, a slope surprise of 25 basis points on FOMC dates leads, on average, to an increase in bank stock return by 1.9% and 2.1%, for the 2 and 10-year Treasury yields respectively.

The explanatory power of the regression, measured by R-squared, is greater in the post-crisis period; now being between 2.7% and 7%. It should be noted that this regression specification differs from that in the pre-crisis period by including a QE dummy variable. The QE dummy control variable is not statistically significant for any maturity of Treasuries.

Table II a)

Interest rate surprises, bank characteristics and bank stock returns 1997–2007

Table II a) reports the results from the OLS regression:

$$R_{it} = \beta_0 + \beta_1 \Delta ff_t^u + \beta_2(\Delta y_t^m - \Delta ff_t^u) + \gamma_1[X_{it} * \Delta ff_t^u] + \gamma_2[X_{it} * (\Delta y_t^m - \Delta ff_t^u)] + \eta_i + \varepsilon_{it}$$

where R_{it} is bank i's simple intraday return factor over the window of policy date t, Δff_t^u is the level surprise, $(\Delta y_t^m - \Delta ff_t^u)$ is the m-year slope surprise, $[X_{it} * \Delta ff_t^u]$ is a vector of certain bank characteristics, denoted by X, interacted with the level surprise, $[X_{it} * (\Delta y_t^m - \Delta ff_t^u)]$ is a vector of certain bank characteristics, denoted by X, interacted with the slope surprise and η_i is a bank specific fixed effect. Standard errors are clustered across time, following the method of English et al. (2018). The columns refer to different maturity horizons (m) for the slope surprise, including the 2-year, 5-year and 10-year Treasury yields respectively. Data regards the pre-crisis period, 1997Q3–2007Q2.

Table II a)

	(1) m = 2-year		(2) m = 5-year		(3) m = 10-year	
VARIABLES	Est.	S.E.	Est.	S.E.	Est.	S.E.
Maturity mismatch x Δff^u	0.0002	(0.0002)	0.0003	(0.0002)	0.0003	(0.0002)
Maturity mismatch x $(\Delta y^m - \Delta ff^u)$	0.0001	(0.0001)	0.0002	(0.0001)	0.0002	(0.0002)
Other assets x Δff^u	-0.0510	(0.0572)	-0.0479	(0.0703)	-0.0461	(0.0964)
Other assets x $(\Delta y^m - \Delta ff^u)$	-0.0023	(0.0517)	0.0063	(0.0513)	0.0033	(0.0683)
Other liabilities x Δff^u	**0.0842****	**(0.0407)**	0.0641	(0.0516)	0.0623	(0.0664)
Other liabilities x $(\Delta y^m - \Delta ff^u)$	0.0076	(0.0367)	-0.0178	(0.0385)	-0.0143	(0.0481)
Deposits x Δff^u	0.0076	(0.0240)	-0.0031	(0.0282)	-0.0211	(0.0384)
Deposits x $(\Delta y^m - \Delta ff^u)$	-0.0203	(0.0252)	-0.0297	(0.0259)	-0.0428	(0.0324)
Market leverage x Δff^u	-0.0013	(0.0021)	-0.0002	(0.0022)	0.0003	(0.0027)
Market leverage x $(\Delta y^m - \Delta ff^u)$	0.0007	(0.0015)	0.0016	(0.0015)	0.0017	(0.0019)
Loans/assets x Δff^u	**0.0604****	**(0.0279)**	**0.0690****	**(0.0313)**	**0.0988*****	**(0.0361)**
Loans/assets x $(\Delta y^m - \Delta ff^u)$	0.0084	(0.0284)	0.0148	(0.0280)	0.0413	(0.0327)
Bank size x Δff^u	**-0.0140*****	**(0.0033)**	**-0.0120*****	**(0.0033)**	**-0.0078***	**(0.0045)**
Bank size x $(\Delta y^m - \Delta ff^u)$	-0.0047	(0.0041)	-0.0021	(0.0037)	0.0025	(0.0043)
Dividend yield x Δff^u	**-0.8855****	**(0.3600)**	**-0.8634****	**(0.3801)**	**-0.9725***	**(0.5010)**
Dividend yield x $(\Delta y^m - \Delta ff^u)$	-0.1892	(0.3559)	-0.1500	(0.3052)	-0.2725	(0.3690)
Level surprise: Δff^u	**0.1336****	**(0.0516)**	**0.0948***	(0.0571)	0.0207	(0.0727)
Slope surprise: $(\Delta y^m - \Delta ff^u)$	0.0417	(0.0538)	0.0007	(0.0492)	-0.0716	(0.0573)
Constant	0.0020	(0.0026)	0.0020	(0.0026)	0.0020	(0.0026)
Observations	17,292		17,292		17,292	
Adjusted R-squared	0.038		0.036		0.032	

Note: Sample period: 84 policy actions between 7/2/1997 and 6/28/2007; No. of banks = 330. Standard errors clustered across time are reported in parentheses. (***, **, *) indicate significance at the 1%, 5%, 10% level. Significant coefficients are in bold.

Not all coefficients are statistically significant. This includes the items English et al. (2018) found in the pre-crisis period.

The effect of banks' maturity mismatch is not statistically significant, but the coefficients would show that banks that hold a larger maturity mismatch are less negatively affected by a rise in interest rates.

In the pre-crisis period, the loan ratio had a statistically significant relationship when interacted with the level surprise. Considering the result in table I a), this implies that banks with large lending businesses, as measured by loans compared to total assets, seem to generally do better during a rise in interest rates.

We also find a statistically significant negative relation between bank size interacted with the level surprise and the bank stock returns. Considering the result in table I a) this implies that the negative effect of an interest rate hike was greater for larger banks. In other words, the negative effect was amplified. Dividend yield behaved in a nearly identical way, while the loan ratio behaved in the opposite way.

However, we would be remiss not to point out that the statistically significant coefficients for the level surprise itself, not interacted with any bank characteristic, in table II a) has flipped compared to table I a). The implications of this are further discussed in our empirical analysis.

Table II b)

Interest rate surprises, bank characteristics and bank stock returns 2012–2019

Table II b) reports the results from the OLS regression:

$$R_{it} = \beta_0 + \beta_1 \Delta ff_t^u + \beta_2(\Delta y_t^m - \Delta ff_t^u) + \beta_3 QE_{\ t}$$
$$+ \gamma_1[X_{it} * \Delta ff_t^u] + \gamma_2[X_{it} * (\Delta y_t^m - \Delta ff_t^u)] + \eta_i + \varepsilon_{it}$$

where R_{it} is bank *i*'s simple intraday return factor over the window of policy date *t*, Δff_t^u is the level surprise, $(\Delta y_t^m - \Delta ff_t^u)$ is the *m*-year slope surprise, $QE_{\ t}$ is a dummy control variable for QE announcements, $[X_{it} * \Delta ff_t^u]$ is a vector of certain bank characteristics, denoted by *X*, interacted with the level surprise, $[X_{it} * (\Delta y_t^m - \Delta ff_t^u)]$ is a vector of certain bank characteristics, denoted by *X*, interacted with the slope surprise and η_i is a bank specific fixed effect. Standard errors are clustered across time, following the method of English et al. (2018). The columns refer to different maturity horizons (*m*) for the slope surprise, including the 2-year, 5-year and 10-year Treasury yields respectively. Data regards the post-crisis period, 2012Q1–2019Q4.

Table II b)

	(1) m = 2-year		(2) m = 5-year		(3) m = 10-year	
VARIABLES	Est.	S.E.	Est.	S.E.	Est.	S.E.
Maturity mismatch x Δff^u	-0.0001	(0.0005)	-0.0005	(0.0005)	-0.0005	(0.0005)
Maturity mismatch x $(\Delta y^m - \Delta ff^u)$	**-0.0003***	**(0.0002)**	**-0.0001****	**(0.0000)**	-0.0001	(0.0002)
Other assets x Δff^u	-0.0105	(0.2248)	0.1872	(0.2363)	0.0818	(0.2066)
Other assets x $(\Delta y^m - \Delta ff^u)$	-0.0691	(0.0649)	-0.0228	(0.0197)	**-0.1267****	**(0.0605)**
Other liabilities x Δff^u	-0.0636	(0.1498)	0.0174	(0.1680)	-0.0240	(0.1640)
Other liabilities x $(\Delta y^m - \Delta ff^u)$	0.0107	(0.0576)	-0.0170	(0.0160)	-0.0211	(0.0551)
Deposits x Δff^u	0.0534	(0.0875)	0.1129	(0.1131)	0.0999	(0.0990)
Deposits x $(\Delta y^m - \Delta ff^u)$	**0.0668****	**(0.0287)**	0.0128	(0.0167)	**0.0751*****	**(0.0262)**
Market leverage x Δff^u	0.0027	(0.0039)	0.0032	(0.0042)	0.0040	(0.0039)
Market leverage x $(\Delta y^m - \Delta ff^u)$	-0.0015	(0.0010)	**0.0001****	**(0.0001)**	-0.0001	(0.0007)
Loans/assets x Δff^u	**-0.3186****	**(0.1381)**	**-0.3523****	**(0.1391)**	**-0.3021****	**(0.1262)**
Loans/assets x $(\Delta y^m - \Delta ff^u)$	0.0424	(0.0406)	0.0230	(0.0190)	0.0409	(0.0420)
Bank size x Δff^u	0.0410	(0.0260)	0.0166	(0.0317)	0.0277	(0.0274)
Bank size x $(\Delta y^m - \Delta ff^u)$	**0.0199*****	**(0.0068)**	0.0034	(0.0043)	**0.0205*****	**(0.0068)**
Dividend yield x Δff^u	-2.8583	(2.2045)	-1.9419	(2.2354)	-0.4788	(2.2400)
Dividend yield x $(\Delta y^m - \Delta ff^u)$	0.4723	(0.6083)	**1.5122****	**(0.6210)**	**1.3072***	**(0.7257)**
Level surprise: Δff^u	-0.2898	(0.4950)	0.0320	(0.5483)	-0.1778	(0.4863)
Slope surprise: $(\Delta y^m - \Delta ff^u)$	**-0.2749****	**(0.1185)**	-0.0691	(0.0763)	**-0.3204*****	**(0.1197)**
QE (control)	-0.0031	(0.0035)	-0.0030	(0.0038)	-0.0027	(0.0034)
Constant	-0.0017	(0.0024)	-0.0016	(0.0024)	-0.0015	(0.0023)
Observations	8,035		8,035		8,035	
Adjusted R-squared	0.064		0.039		0.073	

Note: Sample period: 65 policy actions between 1/25/2012 and 12/11/2019; No. of banks = 174. Standard errors clustered across time are reported in parentheses. (***, **, *) indicate significance at the 1%, 5%, 10% level. Significant coefficients are in bold.

Similarly to our baseline regression, there was a greater explanatory power in the post-crisis period, with more statistically significant coefficients.

The maturity mismatch is now technically significant when interacted with the slope surprise, but its coefficients are small.

This time there was a significant relationship with deposits. Interacted with the slope surprise effect it was positive. Considering the results in table I b), this implies that banks with larger deposit holdings have a larger positive impact on their stock return with a rise in the slope of the yield curve (at least with shorter maturities in mind).

After the financial crisis there has been a reversal and strengthening in the effect of bank size interacted with slope surprise on stock returns, similar to the switch in the effect of the interest rate. Considering the results in table I b), this implies that the larger banks receive a larger positive gain from an increase in the slope of the yield curve, meaning again that bank size amplifies the effect. Dividend yield behaves in a similar way, but only for longer maturities. The loan ratio behaved in the opposite way.

It should be noted that like table II a), the statistically significant coefficients for slope surprise in this regression have flipped compared to table I b).

Table III

Maturity mismatch and interest rates

Table III reports the results from the OLS regression:

$$\Delta GAP_{iq} = \beta_0 + \beta_1 \Delta ff_q^e + \beta_2 \Delta ff_q^u + \beta_4 E_{iq} + \beta_3 L_{iq} + \eta_i + \varepsilon_{iq}$$

where ΔGAP_{it} is the quarterly change in bank i's maturity mismatch (in months) in quarter q, Δff_q^e is the total expected changes in the level of interest rate during quarter q, Δff_q^u is the total level surprises in quarter q, L_{it} is the liquidity ratio and E_{iq} is the equity ratio of bank i in the preceding quarter used as control variables, and η_i is a bank specific fixed effect. Standard errors are clustered on bank holding company level. Column 1 and 2 refer to the pre-crisis period, 1997–2007 and the post-crisis period, 2012–2019, respectively.

Table III

VARIABLES	(1) Pre-crisis	(2) Post-crisis
Expected: Δff_q^e	**-0.639*** **	**-1.854*** **
	(0.201)	**(0.472)**
Level surprise: Δff_q^u	**-4.297*** **	**7.821* **
	(0.991)	**(4.393)**
Equity: E_{iq} (control)	**13.258** **	**-18.930** **
	(5.925)	**(7.942)**
Liquidity: L_{iq} (control)	-2.092	-1.055
	(1.507)	(2.427)
Constant	-0.602	**3.403*** **
	(0.707)	**(1.276)**
Observations	8,351	3,985
Adjusted R-squared	0.004	0.013

Note: Sample pre-crisis period: 84 policy actions between 7/02/1997 and 6/28/2007; No. of banks = 330. Sample post-crisis period: 65 policy actions between 1/25/2012 and 12/11/2019; No. of banks = 174. Standard errors clustered on bank holding company level are reported in parentheses. (***, **, *) indicate significance at the 1%, 5%, 10% level. Significant coefficients are in bold.

In the pre-crisis period, reported in column 1, both the expected variable and the level surprise are statistically significant, with banks' maturity mismatches decreasing for both expected and unexpected increases in the interest rate. The reaction is more economically large for unexpected changes. It should be noted that since we are no longer analyzing stock returns, it is unsurprising that the expected variable is significant.

In the post-crisis period, reported in column two, the expected variable is statistically significant on the same significance level, while the level surprise is significant on the lower 10% level. Also, the coefficient for the level surprise has reversed to become positive. This in turn means that a surprise increase in the interest rate of 25 basis points is equivalent to a decrease in the maturity mismatch on average by 1.1 months in the pre-crisis period and an increase by 1.9 months in the post-crisis.

The R-squared increased from 0.003 in the pre-crisis period to 0.013 in the post-crisis period.

VI. Interpretation of empirical findings

Bank stock returns and interest rates

Our results in the baseline regression are both statistically and economically large in both time periods. Comparing the estimated coefficients in the baseline regressions for the two time periods, it is noticeable that the magnitude of the reaction of bank stock returns to increases in the level of interest rate and slope of the yield curve is greater in the post-crisis period. This result indicates that banks have become more sensitive to interest rate changes after the financial crisis. Importantly, the results also show that the reaction of bank stock returns to increases in the interest rate and slope of the yield curve has reversed after the financial crisis, to become positive. This indicates that, in a low interest rate environment, further interest rate decreases have a negative effect on banks' equity valuations. The fact that bank stock returns react positively to increases in interest rates in the post-crisis period could be a sign of limitations of the effectiveness of conventional monetary policy on banks.

Our results in the pre-crisis period are in line with those of the original study by English et al. (2018) in the direction of the effect of the monetary policy surprises. The results in the post-crisis period are in turn reversed.

Our results in the post-crisis period are similar to those of Ampudia and Van den Heuvel (2018), who also find a reversal from a negative to a positive relationship on the effect of rises in the interest rate on European bank stock returns after the financial crisis, also with a stronger effect. These results thus support the non-monotonic view of the effectiveness of monetary policy in a low interest rate environment, as suggested by Ampudia and Van den Heuvel.

Our results are also consistent with those of Brunnermeier and Koby (2019), who theoretically investigate the existence of a reversal interest rate, the state when interest rate decreases become contractionary as opposed to expansionary for bank lending. These results may indicate that the U.S. has reached a state of a reversal interest rate. This result also empirically supports the notion that, as stated by Brunnermeier and Koby in their paper, the reversal interest rate is not necessarily below zero as commonly thought.

Our results are also in line with the findings of Bailey and Matyáš (2019), who similarly find that bank stocks have become increasingly sensitive to the slope of the yield curve, also finding a reversed effect of a rise in the slope, to a positive one after the financial crisis.

As stated before, since banks stock returns serve as a measure of the overall effect of monetary policy on banks could there be several explanations to the reversed effect of interest rate changes on bank stock returns found in our data. One explanation could be the channel through which the interest rate affects banks' profitability. Bank's are generally positively affected by higher interest rates in that they increase the net interest margin (Borio et al., 2015; Bologna, 2018). Borio et al. (2015) also find a non-linear relationship between bank profitability and interest rates, with the effect of the interest rate on banks' profitability being stronger when the interest rate level is lower and the slope of the yield curve is less steep. Similarly, Claessens et al. (2017) find that a drop in the interest rate lowers banks net interest margin on average, feeding through to bank profitability, and that this effect increases over longer periods with low interest rates.

It is thus intuitive in a low interest rate environment, that is thought of as hurting bank profitability, that rises in the interest rate would have a larger positive effect on banks' net interest margin. According to conventional wisdom, banks will also experience negative effects from an increased interest rate through higher discounting of future cash flows and capital losses from revaluations of fixed rate assets. This is one of the key explanations to the overall negative reaction of bank stock returns to increases in the interest rate in the study by English et al. (2018). By our results however, it seems as if the effect of expected higher future profitability of banks due to rises in the level of the interest rate and the slope of the yield curve outweighs the negative effects of greater discounting from an increased interest rate in the post-crisis period.

The positive reaction of bank stock returns to increases in the slope of the yield curve is in line with conventional thinking that banks benefit from higher long term interest rates in their function of maturity transformation.

According to Brunnermeier and Koby (2019), the reversal interest rate is reached when banks' gains from maturity transformation are insufficient. Banks' gains from their maturity mismatches in a low interest rate environment as the term premium banks earn on maturity transformation decreases with the interest rate (Drechsler et al., 2014). There has been a steep rise of 37% in the average maturity mismatch between the pre-crisis and post-crisis period, during times of steep rate cuts. This could indicate that banks' have adjusted their maturity mismatches to compensate for a decreased term premium, in line with the results of Di Tella and Kurlat (2017).

Following this development, the average maturity mismatch has plateaued and remained at relatively stable levels since 2014 as seen in figure 1. Bologna (2018) shows that higher maturity transformation is beneficial for banks' net interest margins, but also that excessive maturity transformation can be undesirable, with lower net interest margin and higher risk exposure as a result. It could thus be that banks reached a "roof" for the positive effect of increased levels of maturity mismatches in the post-crisis period. With the term premium from maturity transformation decreasing, and with no more room to offset this effect by increasing their maturity mismatches, it could thus be that banks reached the state of insufficient gains from maturity transformation during the post-crisis period. This would mean in turn that a rise in the interest rate could improve banks gains from maturity transformation, partially explaining the reversed reaction of bank stocks to interest rate increases found in our data.

Bank stock returns and bank characteristics

Before continuing with our analysis of the individual bank characteristics, we must address a caveat in our data. For both regressions, II a) and II b), the coefficients for level or slope surprise that remained significant flipped in relation to their respective baseline regressions, in I a) and I b).

There are many factors that determine bank stock returns, monetary policy shocks are but one. This is important to understand since the R-squared values of the baseline regressions were low. This was the case in our study, as well as the study by English et al. (2018). In the study by English et al. the R-squared was approximately 10%, while ours varied between 1.6% and 7%, depending on the regression and maturity used. Thus, especially on the daily time frame used in our data, other factors besides monetary policy can determine a bank's stock returns.

These facts have likely led to the phenomenon seen in tables II a) and II b). This does not negate the results in our baseline regressions I a) and I b). We were expecting a weaker result compared to English et al., since we were using daily stock return data as opposed to high frequency stock data.

What this does mean is that, as an implication for future research, we believe that higher frequency data may be necessary when running regressions with these bank characteristics in order to analyze the effect of monetary policy shocks on bank stock returns, as per the method we have emulated. This is also supported by the fact that maturity mismatch and deposits, two variables English et al. found to be significant when using high frequency data were insignificant in our table II a), the pre-crisis regression.

Any implications we have made as to how bank characteristics interact with these monetary policy shocks must be considered highly tentative. As a result of all of the above, the main focus of our analysis of the results in table II a) and b) will be to attempt to explain variations in effects between the periods, as well as why some variables were significant as opposed to others. We will be interpreting these coefficients assuming that the relationships in tables I a) and I b) apply.

Bank size

A bank characteristic that was significant in both periods was bank size. It was significant when interacted with the level surprise pre-crisis and when interacted with the slope surprise post-crisis. For both periods, considering the results in table I a) and b), the signs of the coefficients imply that an increased bank size amplified the effects of a monetary policy shock, irrespective of the direction of that effect. English et al. (2018) found the same in their original study as well. The coefficient was negative and statistically significant in their regression, which corresponds to our pre-crisis regression in table II a).

One reason for this could be that on average, larger banks were more likely to use financial derivatives in the pre-crisis period. This was a conclusion in a study previously mentioned by Drechsler et al. (2018), as well as the original study by English et al. (2018). According to Begenau et al. (2015), these derivatives tended to be used to increase exposure to positions, not to hedge. Thus, the presence of these derivatives can make larger banks somewhat more volatile and vulnerable to monetary policy shocks.

Considering the explanation above, the fact that this effect seems to remain in the post-crisis period may be puzzling. New regulation has obliged larger banks to take fewer risks, and increase their capital reserves, so as to better absorb shocks. One explanation could be a different approach to “too big to fail” banks. For example, Atkeson et al.’s, (2018) study *Government guarantees and the valuation of American Banks* come to the conclusion that after the financial crisis the contribution of government guarantees to bank valuations decreased. If the market senses a reduced likelihood of bailouts for large banks, then it stands to reason that these banks’ shares would become more sensitive to whatever shocks occur as a result. When government guarantees contribute less to valuations, other factors become more important.

Dividend yield

The dividend yield of banks’, interacted with the level and slope surprises behaved in a very similar manner to bank size, which according to our interpretation means that it amplifies effects that were present. That stocks with higher dividend yield are more volatile is in line with conventional wisdom.

Interestingly, the larger banks in our study were inclined to have larger dividend yields on average during both periods. (see table 8 in the appendix). This relationship was far stronger in the pre-crisis period. With this in mind, it does not seem shocking that dividend yield and bank size would interact with the monetary policy shocks in the same way. It should be noted that dividend yield was not a part of the original study by English et al. (2018).

Loan to asset ratio

The fact that the loan to asset ratio behaved in the opposite way to bank size and dividend yield can be analyzed similarly. When a basic OLS regression is run, it is determined that the loan ratio has a statistically significant negative correlation with bank size (see table 9 in the appendix).

Considering the results in tables I a) and I b), the coefficients for the loan to asset ratio in tables II a) and II b) imply that a large loan to asset ratio dampened the effects from monetary policy shocks. In other words banks that focus more on lending are less volatile than the average bank.

According to our prior reasoning, this could be because they do not employ financial derivatives and riskier strategies to the same extent as the larger banks. It should be noted though that loan to asset ratio did not have any statistically significant relationships in the original study by English et al. (2018). Like the other relationships with bank characteristics, this implication should be considered very tentatively.

Deposits

Departing from considerations of bank size, the proportion of deposit financing was a significant variable in the original study by English et al. (2018) that amplified the negative effects of an interest rate hike in the pre-crisis period. As previously stated, this variable was not significant in our regression II a) for the pre-crisis period, implying that the relationship cannot be isolated in daily data for the same time period.

However, in the post-crisis period the same variable was statistically significant. The positive coefficient for the interacted variable, considering the results in table I b), implies that a larger share of deposit financing amplified the positive effect from an unexpected increase in the slope of the yield curve.

This could be due to the low interest rate environment. In the current situation the interest rate paid to basic, liquid checking and savings accounts is relatively low. There is evidence that interest rates paid on deposits easily go down, but are "sticky" when moving upward (Hannan and Berger, 1991) (Neumark and Sharpe, 1992). This is likely to be especially true in the current low interest rate environment, and should be noticeable compared to wholesale financing. In such a situation, when interest rates rise banks with larger amounts of deposits relative to wholesale financing will see a smaller increase in costs meaning that those banks can better exploit the positive effects from an increase in the interest rate.

In addition, the average deposit share of liabilities for a bank in our dataset has increased from 42% during the pre-crisis period to 60% in the post-crisis period (see descriptive statistics in tables 6 and 7 in the appendix) implying that "sticky up" effects for deposit rates have become more important and are benefiting the entire banking sector as a whole in the post-crisis period.

This line of reasoning may also help explain why rising rates have become positive for banks in the post-crisis period at all. While interest rates paid on personal bank accounts are “sticky up”, the average net interest margin should increase more in a banking sector that has a larger share of deposit financing.

Maturity mismatch

Maturity mismatch had a significant relationship in the original study by English et al. (2018). They determined that a large maturity mismatch dampened the negative effect of an increase in the interest rate. Similarly to deposits, this variable was not significant in our version of English et al.’s pre-crisis regression in table II a). It was however significant in the post-crisis period, the regression in table II b).

The statistically significant coefficients are small, but the negative sign implies that a greater maturity mismatch also dampens the positive effects from an increase in the slope of the yield curve. This defies conventional wisdom, since a larger slope of the yield curve increases the net interest margin of banks with maturity mismatch.

If this is not merely a statistical anomaly, an explanation could be that in this case the maturity mismatch is a secondary indicator of another relationship. Banks who are riskier for reasons we have previously discussed will probably possess more volatile assets that, coincidentally, are of shorter maturity compared to safer assets such as mortgages.

Maturity mismatch and interest rates

The results in table III show that banks’ maturity mismatches react relatively swiftly to changes in the interest rate. In the pre-crisis period as a response to surprise increases (decreases) in the interest rate, banks’ maturity mismatches decrease (increase). This is in line with conventional thinking regarding the impact of the interest rate on banks’ business, as contractionary monetary policy will increase the opportunity cost of holding cash, which leads to an increased demand for bank deposits, increasing the weight of liabilities in the maturity mismatch. At the same time, contractionary monetary policy decreases bank lending through higher borrowing costs and leads to impaired bank assets from revaluations, leading to decreased asset weight in the maturity mismatch.

Our result in the pre-crisis periods is in line with those of Di Tella and Kurlat (2017), who find that banks' maturity mismatches tend to increase in times of low interest rates, and vice versa, due to an increased sensitivity in the term premium between risky and safe assets.

Comparing the results in the pre-crisis period with the post-crisis period, it is noticeable that the reaction of banks’ maturity mismatches to level surprises has reversed to become positive after the financial crisis. This can be interpreted as contractionary monetary policy having a positive effect on banks' maturity mismatches, while expansionary monetary policy has a negative effect. This goes against the results of Di Tella and Kurlat mentioned before, and conventional thinking regarding interest rates and banks loan supply.

Instead, this result is in line with the notion of the reversal interest rate mentioned before by Brunnermeier and Koby (2019), where expansionary monetary policy has a reversed effect on bank lending.

The result in the post-crisis period is also in line with the results of Borio and Gambacorta (2017) who find that in a low interest rate environment expansionary monetary policy is less effective in increasing bank lending growth. They suggest that this is partially due to the negative effect low interest rates have on the profitability of bank lending, which in turn decreases banks' ability and incentives to supply loans. As discussed before, increases in the interest rate do improve banks' net interest margins, especially in a low interest rate environment, which in turn should have a positive effect on bank lending, leading to an increase in the maturity mismatch following our definition.

VII. Conclusion

In this paper we analyze how unexpected changes in the federal funds rate affect U.S. bank holding companies' stock returns on FOMC days in a period before the financial crisis of 2008 and a period after the crisis. We do this in large part by replicating the method in English et al. (2018), with some modifications.

Our results show that bank stock returns were negatively affected by increases in the level of interest rate and slope of the yield curve before the crisis and that the opposite is true after the financial crisis. Our results are both statistically and economically large in both time periods. The pre-crisis results conform with the original study by English et al. (2018) but are weaker, which is to be expected considering our use of daily data. The post-crisis results show that banks have become increasingly sensitive to interest rate changes and conform with other literature in this area, and imply that the United States may have already reached a state of reversal interest rate, where banks react positively to contractionary monetary policy.

When bank characteristics were interacted with these monetary shocks some problems arose. Coefficients for the level and slope surprise flipped in the pre- and post-crisis periods compared to their respective baseline regressions where no bank characteristics were analyzed. This implies that daily stock data may not be suitable for analyzing specifically how bank characteristics interact with bank stock returns and monetary policy shocks.

However, the regressions imply that larger banks with higher dividend yields and a greater share of deposit financing were affected to a greater extent by monetary policy shocks than other banks on average, whereas banks with greater loan-to-asset ratios and maturity mismatches were less affected. This is plausible considering conventional wisdom and available literature on these topics.

Finally, we analyzed the effect of unexpected changes in the federal funds rate on banks' maturity mismatches to illustrate how they adapt to changes in policy. Increasing interest rates reduce banks' maturity mismatches in the pre-crisis period, in line with previous literature. In the post-crisis period, however, banks' maturity mismatches increases with positive level surprises. This result is in line with the notion of a reversal interest rate, also indicated by our baseline results in the post-crisis period.

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Appendix

Summary statistics

Table 4. - Summary statistics of monetary policy shocks, 1997–2007

VARIABLES	Mean	SD	Min	Max
Level surprise: Δff^u	-0.015	0.083	-0.480	0.110
Expected change: Δff^e	0.018	0.189	-0.510	0.450
Slope surprise: $(\Delta y^2 - \Delta ff^u)$	0.006	0.094	-0.180	0.530
Slope surprise: $(\Delta y^5 - \Delta ff^u)$	0.007	0.103	-0.160	0.660
Slope surprise: $(\Delta y^{10} - \Delta ff^u)$	0.010	0.104	-0.140	0.700

In percent

Table 5. - Summary statistics of monetary policy shocks, 2012–2019

VARIABLES	Mean	SD	Min	Max
Level surprise: Δff^u	0.002	0.014	-0.050	0.030
Expected change: Δff^e	0.021	0.101	-0.240	0.250
Slope surpris: $(\Delta y^2 - \Delta ff^u)$	-0.007	0.046	-0.150	0.110
Slope surprise: $(\Delta y^5 - \Delta ff^u)$	0.004	0.123	-0.140	0.860
Slope surprise: $(\Delta y^{10} - \Delta ff^u)$	-0.005	0.052	-0.120	0.120

In percent

Table 6. - Summary statistics of bank characteristics, pre-crisis period, 1997–2007

VARIABLES	Mean	SD	P50	Min	Max
Maturity mismatch[a]	47.06	24.54	43.92	0.06	113.06
Maturity mismatch assets[a]	51.05	24.85	47.86	0.06	121.63
Maturity mismatch liabilities[a]	3.97	2.20	3.70	0.00	19.06
Other assets[b]	0.12	0.22	0.03	0.00	1.00
Other liabilities[c]	0.20	0.17	0.16	0.00	1.00
Market leverage	7.14	3.22	6.45	2.00	55.96
Deposits[c]	0.42	0.14	0.40	0.00	0.94
Total loans[d]	0.66	0.11	0.67	0.15	0.94
Dividend yield[e]	0.03	0.02	0.03	0.00	0.29
Total assets[f]	18.48	99.69	1.56	0.10	2220.00

[a] In months.
[b] As a share of total interest-earning assets.
[c] As a share of total liabilities.
[d] As a share of total assets.
[e] As a share of total equity capital
[f] In billions of dollars.

Table 7. - Summary statistics of bank characteristics, post-crisis period, 2012–2019

VARIABLES	Mean	SD	P50	Min	Max
Maturity mismatch[a]	64.56	21.65	63.26	16.98	123.72
Maturity mismatch assets[a]	67.43	21.66	66.13	17.27	129.77
Maturity mismatch liabilities[a]	2.87	1.94	2.46	0.00	12.46
Other assets[b]	0.06	0.08	0.03	0.00	0.59
Other liabilities[c]	0.11	0.09	0.09	0.00	0.75
Market leverage	9.76	12.09	7.44	2.49	362.59
Deposits[c]	0.60	0.14	0.60	0.17	0.96
Total loans[d]	0.66	0.12	0.68	0.13	0.89
Dividend yield[e]	0.02	0.02	0.01	0.00	0.30
Total assets[f]	42.25	236.00	4.32	0.31	2760.00

[a] In months.
[b] As a share of total interest-earning assets.
[c] As a share of total liabilities.
[d] As a share of total assets.
[e] As a share of total equity capital
[f] In billions of dollars.

Table 8. - OLS regression between Dividend Yield and Bank Size

	(1)	(2)
VARIABLES	Pre-crisis Dividend yield	Post-crisis Dividend yield
Bank size	0.0038***	0.0013***
	(0.0001)	(0.0001)
Constant	-0.0254***	-0.0022
	(0.0015)	(0.0020)
Observations	18,118	8,383
R-squared	0.074	0.013

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9. - OLS regression between Loan-to-asset ratio and Bank size

	(1)	(2)
VARIABLES	Pre-crisis Loans	Post-crisis Loans
Bank size	-0.012***	-0.016***
	(0.000)	(0.001)
Constant	0.847***	0.905***
	(0.007)	(0.013)
Observations	18,118	8,383
R-squared	0.034	0.039

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

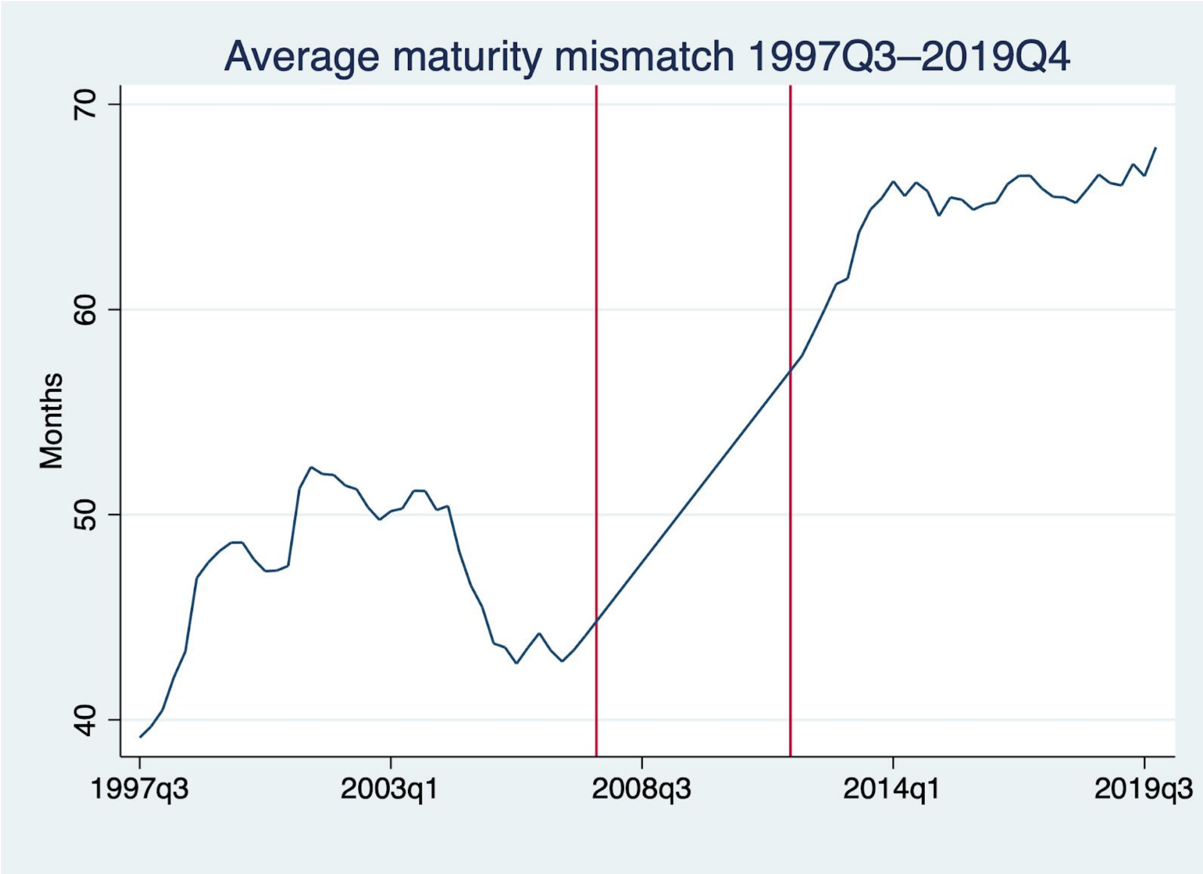

Figure 1. Average maturity mismatch. Figure 1. plots the average maturity mismatch per quarter of our sample banks over the period 1997Q3–2019Q4. The red lines represent the time period 2007Q3–2011Q4, which is excluded from our pre- and post-crisis time periods.

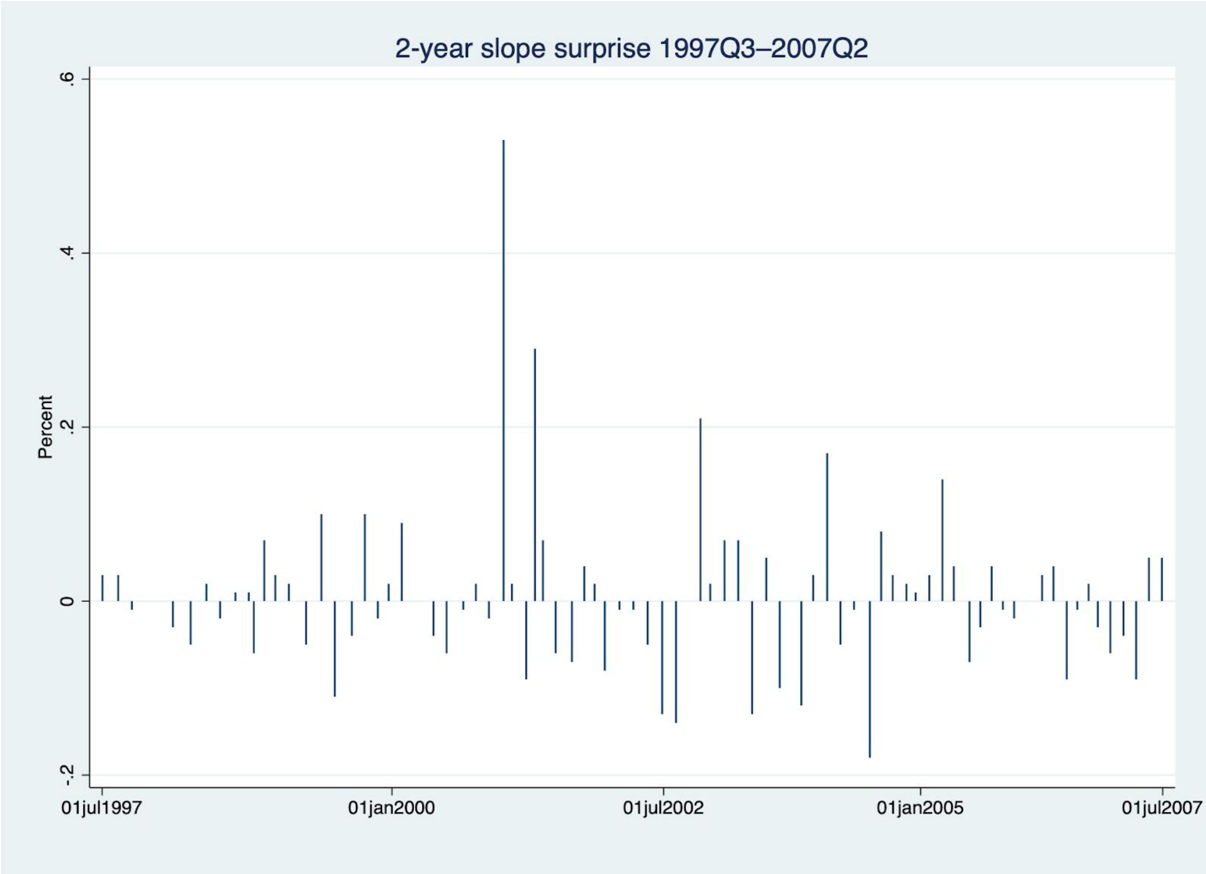

Figure 2. 2-year slope surprise pre-crisis period. Figure 2. plots the 2-year slope surprise on FOMC dates during the pre-crisis period, 1997Q3–2007Q2

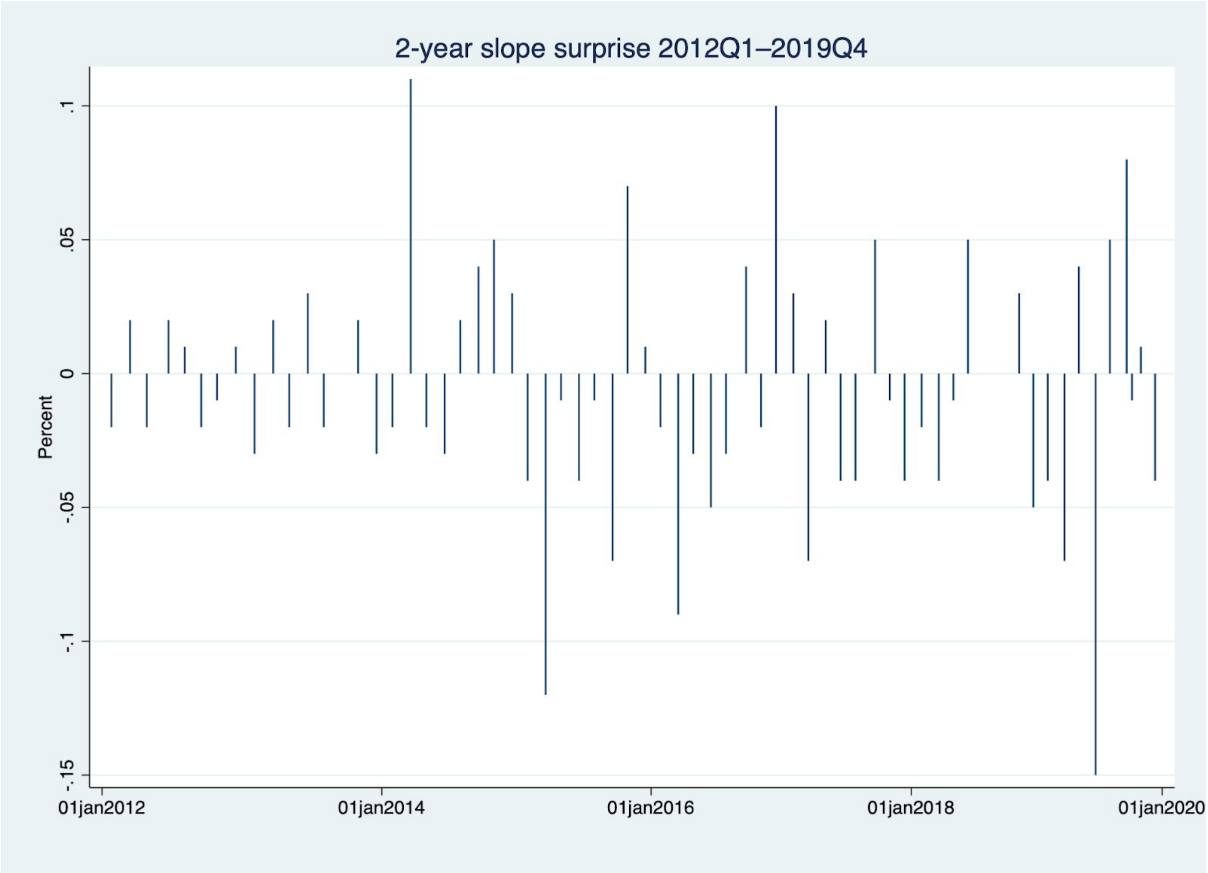

Figure 3. 2-year slope surprise post-crisis period. Figure 3. plots the 2-year slope surprise on FOMC dates during the post-crisis period, 2012Q3–2019Q2

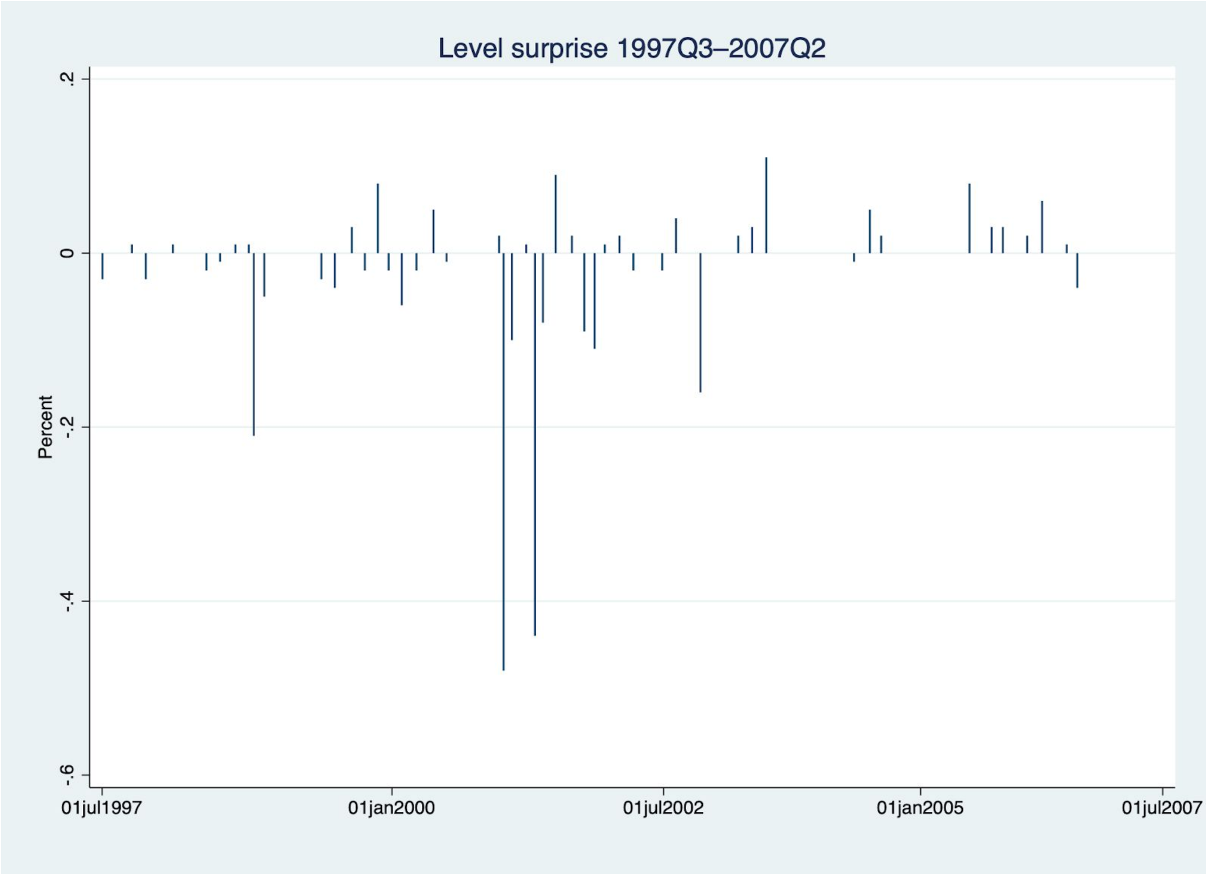

Figure 4. Level surprise pre-crisis period. Figure 4. plots the level surprise on FOMC dates during the pre-crisis period, 1997Q3–2007Q2

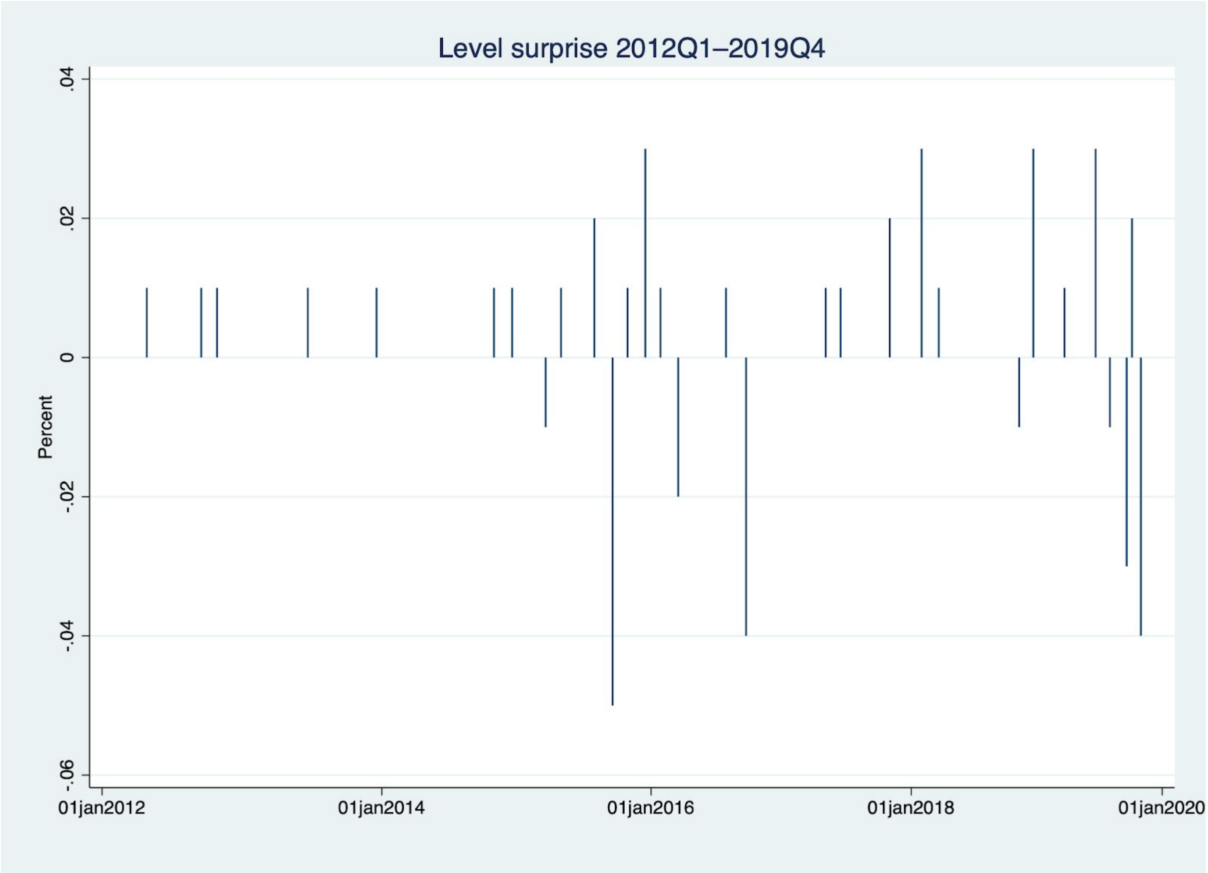

Figure 5. Level surprise post-crisis period. Figure 5. plots the level surprise on FOMC dates during the post-crisis period, 2012Q1–2019Q4

Maturity mismatch

For the calculation of a bank's maturity mismatches, we use the 26 asset items and the 11 liability items with repricing data available in call reports filed by U.S. commercial banks.

These items are defined in the Federal Reserve's Micro Data Reference Manual, available here: https://www.federalreserve.gov/data/mdrm.htm

Asset items gathered from call reports includes:
RCB (securities): RCFDA549–554, RCONA549–554, RCFDA555–562, RCONA555–562
RCC (loans): RCFDA570–575, RCONA570–575, RCONA564–569

Liability items gathered from call reports for the period 1997–2016 includes:
RCE: RCON6810, RCON0352, RCON2215, RCONA579–582, RCONA584–587

The liability items gathered from call report for the period 2017-2019 includes:
RCE: RCON6810, RCON0352, RCON2215, RCONHK07–10, RCONHK12–15

To calculate the weighted-average repricing/maturity period of assets and liabilities for in our maturity mismatch calculations, we follow the methodology of English et al. (2018) and assign a midpoint value for the repricing period described in the call report instructions (in months). These include, for example, items maturing in 3–12 months assigned a repricing period of 7.5 months and items maturing in 3–5 year assigned a repricing period of 48 months. Items at the end with no interval are assigned repricing periods: over 3 years = 60 months, over 15 years = 240 months. Money market deposit accounts, transaction accounts and non-transaction savings accounts are included at their contractual repricing time, which according to the call report instructions is 0 months.

Sample selection criteria

To prevent outliers from biasing our results we took measures to narrow the selection of admissible observations. Observations with an absolute daily stock return of over 10% were removed. Observations with 0 total loans were removed. Observations with a maturity mismatch outside of a span between the 1st and 99th percentiles were removed. If an observation's maturity mismatch ended up being negative by our calculations, meaning that the liabilities had on average a greater maturity than the assets, it was also removed.

Bank characteristics

The bank characteristics used in this paper are calculated as follows. The item codes (e.g. BHCK0395) are used in FR Y-9C regulatory filings to identify specific items. These codes were also present in the data we used. See replication files for more detail.

Earning Assets = Interest-bearing balances due from depository institutions (BHCK0395 and BHCK0397) + securities (BHCK1754 and BHCK1773) + quarterly average of federal funds sold and securities purchased under agreements to resell (BHCK3365) + loans and leases, net of unearned income (BHCK2122) + trading assets (BHCK3545)

Other assets = Earning assets (as defined above) - Sum of call report assets items (described above)

Other liabilities = Total liabilities and minority interest (BHCK2948) - Sum of call report liability items (described above)

Other assets (as a share of interest earning assets) = Other assets (as defined above) / Earning assets (as defined above)

Other liabilities (as a share of total liabilities) = Other liabilities (as defined above) / Total liabilities and minority interest (BHCK2948)

Deposits = [Total non-transactions savings deposits (BHCB2389) + Total demand deposits (BHCB2210)] / Total liabilities and minority interest (BHCK2948)

Market leverage = [Total assets (BHCK2170) - Total equity capital (BHCK3210) + Market capitalization] / Market capitalization

Loans = Total loans and leases (BHCK2122) / Total assets (BHCK2170)

Bank Size = log[total assets (BHCK2170)]

Dividend Yield = Cash dividends declared on common stock (BHCK4460) / Total Equity Capital (BHCK3210)

Liquidity = [Available for sale securities (BHCK1773) + Held to Maturity Securities (BHCK1754)] / Total assets (BHCK2170)

Equity = Total equity capital (BHCK3210) / Total assets (BHCK2170)