J. Finan. Intermediation 53 (2023) 101003

Contents lists available at ScienceDirect

Journal of Financial Intermediation

journal homepage: www.elsevier.com/locate/jfi

Monetary policy effects in times of negative interest rates: What do bank stock prices tell us?☆

Joost V. Bats [a,b,*], Massimo Giuliodori [b,c], Aerdt C.F.J. Houben [b,d,e]

[a] Reserve Bank of Australia, Australia
[b] University of Amsterdam, The Netherlands
[c] Tinbergen Institute, The Netherlands
[d] De Nederlandsche Bank, The Netherlands
[e] Organisation for Economic Co-operation and Development, France

ARTICLE INFO

JEL classification:
E43
E44
E52
G12
G21

Keywords:
Monetary policy
Bank stock prices
Negative interest rates

ABSTRACT

This paper investigates bank stock performance following different monetary policy actions in times of positive and negative interest rates. Controlling for the broader stock market, monetary policy announcements that cause an unanticipated downward shift in the yield curve and a flattening of the shorter-end of the yield curve are found to persistently reduce bank stock prices once the interest rate environment is negative. Consistent with the deposits channel of monetary policy, the effects are larger and more persistent for banks that are relatively dependent on deposit funding. By contrast, a surprise movement in the slope of the longer-end of the yield curve does not impact bank stock prices in times of negative interest rates. Accounting data confirm that a parallel drop in the yield curve following a monetary policy decision in a negative interest rate environment hurts banks through shrinking deposit margins.

1. Introduction

Over the past 40 years, interest rates have steadily declined worldwide, recently turning negative in Europe and Japan (Fig. 1). In Europe and Japan, interest rates are expected to remain negative and yield curves flat for long. A prolonged period of negative interest rates has implications for the performance of banks, as retail deposit rates are sticky at the zero lower bound. In a negative interest rate environment, additional rate cuts may reduce bank profits, particularly if these endure. This can lead to financial instability (Porcellacchia, 2020) and 'reverse' accommodative monetary policy by reducing the lending capacity of capital-constrained banks (Claudio and Gambacorta, 2017; Brunnermeier and Koby, 2018; Cavallino and Sandri, 2018; Gropp et al., 2019; Gomez et al., 2021).

Despite retail customers' ability to clear their sight deposit balances at any point in time, retail deposits are a stable funding source for banks and thus have a positive duration. Hoffmann et al. (2019) estimate the average duration of retail sight deposits at 2 years.[1] In practice, banks replicate portfolios of fixed-rate assets that match the estimated duration of their deposit liabilities (Kalkbrener and Willing, 2004) using interest rate swaps (Jarrow and van Deventer, 1998). The difference between the swap and deposit rates represents the deposit margin (Fig. 2, bracket C). While banks may supply loans with an average duration longer than their replicating portfolio (Fig. 2, bracket B), the remaining interest rate exposure is generally small since banks match the sensitivities of their interest income and expenses (Drechsler et al., 2021), and use interest rate derivatives to hedge their assets (e.g. Chaudron, 2018; Hoffmann et al., 2019).[2] In addition, banks earn

☆ The views expressed are those of the authors and do not necessarily reflect the position of the European Central Bank, De Nederlandsche Bank or the Reserve Bank of Australia. We thank Maurice Bun, Marco Casiraghi, Jorien Freriks, Gaston Gelos, Jakob de Haan, Tom Hudepohl, Jan Kakes, Klaas Knot, José Martin-Flores, Yvo Mudde, René Rollingswier, João Santos, Oscar Soons and one anonymous referee for valuable comments, as well as conference participants at the Southwestern Finance Association 2021 Annual Meeting and the 2020 Netherlands Economist week, and seminar participants at the International Monetary Fund and Netherlands Central Bank.

* Corresponding author.
E-mail addresses: batsj@rba.gov.au (J.V. Bats), m.giuliodori@uva.nl (M. Giuliodori), a.c.f.j.houben@dnb.nl (A.C.F.J. Houben).

[1] Hoffmann et al. (2019) show the duration of retail deposits can be larger than 2 years, because they estimate the standard deviation of the retail deposits' duration at 1.6 years.

[2] However, Begenau et al. (2020) show that the larger US banks continue to be relatively exposed to interest rate risk.

[3] For banks that rely on deposit funding, the deposit and lending margin make up the net interest margin.

https://doi.org/10.1016/j.jfi.2022.101003
Received 25 January 2021; Received in revised form 18 October 2022; Accepted 22 October 2022
Available online 31 October 2022

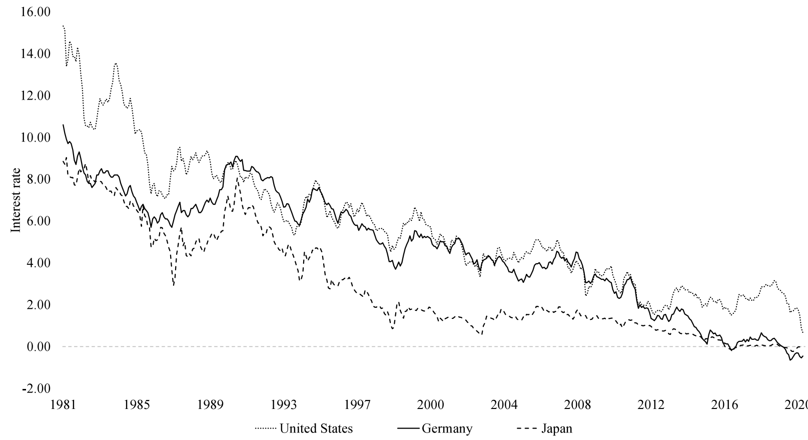

Fig. 1. 10-year government bond yield developments. *Notes:* This figure shows developments in the 10-year government bond yields for Germany, Japan and the United States. *Data source:* Federal Reserve Bank of St. Louis.

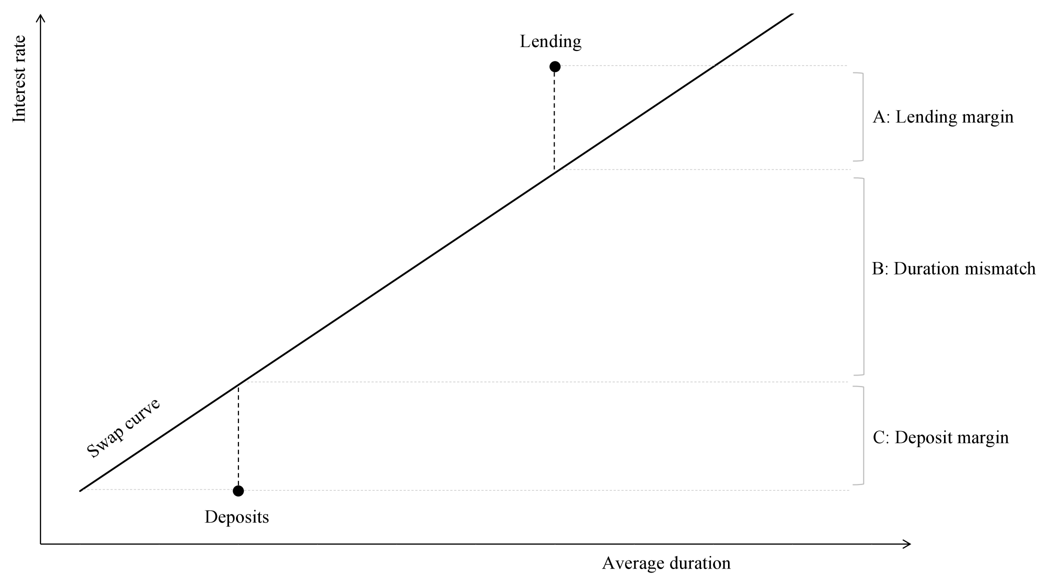

Fig. 2. The net interest margin.
Notes: This figure illustrates banks' net interest margin in a nominal interest rate environment with a positively sloped yield curve. The vertical axis represents the interest rate. The horizontal axis is the average duration. To match the duration of deposit liabilities, banks use replicating portfolios equivalent to particular interest rate swaps. The difference between the swap and deposit rates represents the deposit margin (bracket C). The difference between the swap and lending rates is the lending margin (bracket A). The interest rate exposure resulting from the duration mismatch between replicating portfolios and lending (bracket B) is generally hedged.

a lending margin, defined as the difference between the rate on lending and swap contracts with an equivalent average duration (Fig. 2, bracket A).[3] The relationship between swap rates at different maturities is identified as the swap curve, which is the equivalent of a risk-free yield curve.

Monetary policy shapes the yield curve in different ways (see also Altavilla et al., 2019). First, changing the central bank's policy rate affects interest rates with maturities up to 1 to 2 years. However, a policy rate cut in negative territory may influence interest rates with maturities up to 5 years almost equivalently, if it signals the effective lower bound on interest rates is lower than previously perceived by market participants (Lane, 2019). Second, providing forward guidance on a central bank's future monetary policy intentions may affect interest rates with maturities between 2 and 5 years. Third, offering central bank longer-term refinancing operations, which fund banks for periods up to 4 years, influences interest rates with maturities up to 4 years. Fourth, purchasing long-term bonds under quantitative easing policies mostly impacts interest rates with maturities of 5 years and longer. Fifth, targeting longer-term interest rates under yield curve control policies, as implemented by the Bank of Japan, affects interest rates with maturities of around 10 years.[4]

As a result of retail deposit rates bound at zero, monetary policy effects on the yield curve can hurt bank performance and impede the monetary transmission when policy rates are negative.[5] This is in line with the deposits channel of monetary policy (Itamar et al.,

[4] While short-term interest rates have not been driven far in negative territory, the Bank of Japan has effectively steered the 10-year yield to flatten the longer-end of the curve. The Australian Reserve Bank has also undertaken yield curve control, albeit their intention was to reinforce the central bank's forward guidance by targeting shorter-term interest rates.

[5] Bank performance not only depends on the net interest margin, since a share of bank revenue stems from fee income. As such, banks may try to offset interest income losses under a low and negative interest rate regime by shifting

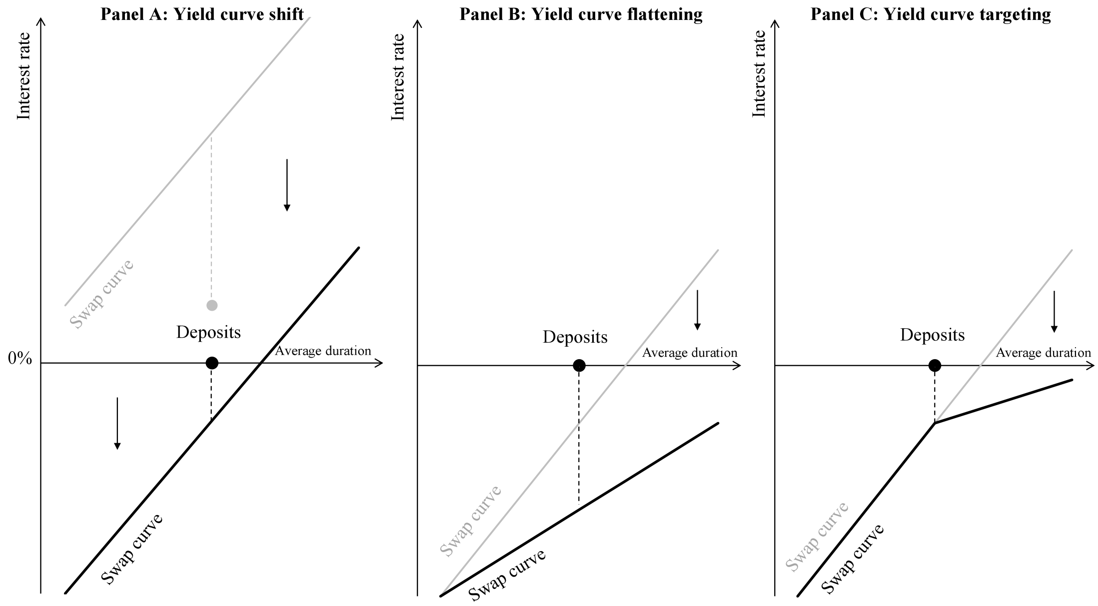

Fig. 3. Monetary policy and the deposit margin when interest rates are negative.
Notes: This figure depicts the stylized impact of a negative interest rate environment on banks' deposit margins. The vertical axis represents the interest rate. The horizontal axis is the average duration. In this figure, deposit rates are bound at zero. Panel A shows deposit margins permanently shrink and turn negative following a downward parallel yield curve shift into a negative interest rate territory. Panel B shows that in a negative interest rate environment, yield curve flattening makes deposit margins even more negative, since sight deposits effectively have a duration larger than 0. Panel C indicates that in times of negative interest rates, deposit margins are less affected when only the longer-end of the yield curve flattens.

2017). When the yield curve shifts downward in a negative interest rate environment, the deposit margin shrinks and eventually turns negative (Fig. 3, Panel A). Subsequent yield curve flattening can turn the deposit margin even more negative, despite banks hedging the remaining interest rate exposure, as banks match the duration of deposits with replicating portfolios (Fig. 3, Panel B). However, the deposit margin may be less affected if only the longer-end of the yield curve flattens (Fig. 3, Panel C). By contrast, changes to the yield curve do not necessarily affect the lending margin. The lending margin mainly represents a credit risk premium and is not constrained in a negative interest rate environment. While the lending margin temporarily increases thanks to a delayed decline in interest income on account of banks' fixed rate assets having a longer duration (i.e. accruing capital gains), it is expected to return to its original size over time.

The empirical literature shows that a low and negative interest rate environment has negative effects on the performance of banks (see e.g. Borio et al., 2017; Claessens et al., 2018; Eggertsson et al., 2019; Freriks and Kakes, 2021; Florian et al., 2019, although some studies indicate the adverse implications for bank performance are limited (see e.g. Altavilla et al., 2018; Lopez et al., 2020; Altavilla et al., 2022). These studies measure bank performance using balance sheet and income statement items such as the net interest margin, lending and profitability (see Brandão-Marques et al., 2021; Balloch et al., 2022, for comprehensive literature reviews). The advantage of these measures is that they are based on actual reported bank performance data. However, their caveat is that they are backward-looking and do not reflect the full impact of negative interest rates, which takes time to materialize. Backward-looking measures only respond to a drop in the interest rate with a lag due to banks' capital gains on fixed rate assets. In terms of the sustainability of bank profits, backward-looking indicators may in fact be biased. Several studies show that banks temporarily respond to negative interest rates by increasing their lending volumes (Basten and Mariathasan, 2018; Demiralp et al., 2019; Tan, 2019; Bottero et al., 2022), but a prolonged negative interest rate environment may require banks to eventually increase lending margins (see also Eggertsson et al., 2019, which will reduce their lending volumes, market share and profits. In addition, backward-looking data are generally reported at a low frequency, complicating the identification of monetary policy effects on bank performance in times of negative interest rates.

To address these caveats, this paper explores the impact of negative interest rates on bank performance using a forward-looking indicator: bank stock prices. These reflect the market valuation of banks' equity based on the expected future discounted cash flows at any given time. Bank stock prices therefore provide a forward-looking indicator of the impact of interest rate changes on bank performance. A drop (rise) in bank stock prices following a change in the interest rate or slope of the yield curve indicates that investors expect lower (higher) future discounted cash flows. Stock prices can therefore be considered a 'summary measure' of bank performance ((Ampudia and den Heuvel, 2022). As bank stock prices may anticipate changes to the yield curve in the future, this paper separates the impact of monetary policy by identifying unanticipated interest rate changes on the basis of high-frequency data around 269 ECB monetary policy announcements from January 1999 to January 2020. The analysis focuses on the Eurosystem since the interest rate environment has been more negative in the euro area than in other major currency areas.

Three recent papers have also analyzed the effect of unanticipated interest rate changes around monetary policy announcements on bank stock prices.[6] English et al. (2018)) look at the US in a positive interest rate environment and show that bank stock prices drop when the yield

towards more fee-related activities, as well as by charging higher fees (Brei et al., 2019; Lopez et al., 2020)

[6] Several other studies use high-frequency data for the identification of unanticipated interest rate changes, but bank stock price developments are not the main focus of these studies (e.g. Bagliano and Favero, 1999; Kuttner, 2001; Cochrane and Piazzesi, 2002; Faust et al., 2004; Bernanke and Kuttner, 2005; Gürkaynak et al., 2005; Piazzesi and Swanson, 2008, .

curve unexpectedly shifts upwards or steepens. This may reflect banks' hedging activity and a combination of capital losses on longer-term assets, higher discount rates on future earnings, higher expected credit losses and/or lower anticipated economic activity due to monetary tightening. Hong and Kandrac (2018) look at Japan and show that bank stock prices dropped by more than 5% on the day the Bank of Japan announced their negative interest rate policy. Ampudia and den Heuvel (2022) focus on Europe and find that a drop in the 1-month interest rate, holding the 2-year yield constant, increases bank stock prices in a positive interest rate environment, but reduces bank stock prices in a low and negative rate environment. The findings of the latter two papers are consistent with a decline in banks' future profits due to lower net interest margins when the interest rate environment turns negative. Conversely, however, Ampudia and den Heuvel (2022) show that an unanticipated flattening of the 2-year yield curve increases European bank stock prices in times of negative interest rates. The increase in bank stock prices may reflect a positive response to lower discount rates on future earnings and/or higher anticipated economic activity due to monetary easing.

The goal of this paper is to investigate whether bank stock prices react differently to monetary policy impacting the shorter- versus the longer-end of the yield curve in times of positive and negative interest rates. Ampudia and den Heuvel (2022) show that the effect of a short-term rate surprise on bank stock prices depends on the interest rate environment. This study builds on that finding by assessing whether the specific design of monetary policy impacts bank performance when interest rates are negative. Given the introduction of unconventional monetary policy instruments, it is important to make a distinction between the different instruments central banks may use to intervene on different segments of the yield curve. For example, large-scale purchases of longer-term assets can be implemented such that only the longer-end of the yield curve is targeted, leaving shorter-term interest rates relatively unchanged. This may reduce the adverse impact of monetary policy on bank performance in a negative interest rate environment. By the same token, the adverse effects on bank stock prices of a downward shift and flattening of the entire yield curve may stem mostly from changes to shorter-end rates up to the 5-year yield. In addition, to confirm how the implementation of monetary policy in a negative interest rate environment hurts banks through shrinking deposits margins, this paper supplements the analysis of stock prices with a study of bank balance sheet and income statement items.

To provide insight into how the impact of monetary policy accrues over time in a negative interest rate environment, this paper employs rolling regressions. Similar to the state-dependent model applied by Ampudia and den Heuvel (2022), a rolling regression model can quantify how bank stock prices are affected as the interest rate environment changes. The negative impact of a rate drop on bank performance likely increases over time when interest rates remain negative for longer. Moreover, rolling estimations can show whether a drop in the interest rate already reduces bank performance in a low but positive interest rate environment due to shrinking deposit margins. To gauge the persistence of the effects, the rolling regressions also assess the developments in bank stock prices the days after the monetary policy decisions.

Moreover, in contrast to the above papers, this study identifies the specific disadvantage banks face in times of negative interest rates by controlling for broad stock market movements. While the monetary policy surprises in the above papers do not necessarily reflect structural macroeconomic developments (Mark and Karadi, 2015), they generate endogenous signaling effects when they represent unexpected changes to the macroeconomic outlook (Emi and Steinsson, 2018; Jarociński and Karadi, 2020). This impacts stock prices in general. In addition, a drop in the interest rate may increase stock prices when it leads to capital gains, a decrease in discount rates and/or equity risk premiums, and an increase in economic activity (see also Bernanke and Kuttner, 2005). This contrasts with the specific negative effect of interest rate reductions on bank stock prices when banks' expected future cash flows decline as a result of deposit margins turning negative. To address these identification issues, this paper analyzes the effect of monetary policy surprises on bank stock prices while controlling for broad stock market prices. The broad stock market is assumed to also react to unexpected interest rate changes and their resulting macroeconomic signaling effects, while being insensitive to the specific additional negative effect of interest rate declines on banks' deposit margins in times of negative interest rates. To address potential concerns that the results may be driven by the impact of monetary policy on the equity beta of banks, or on the broader market through banks' performance in times of negative interest rates, this paper also estimates the effects of monetary policy surprises on the idiosyncratic return of bank stock prices.

The results suggest central banks need be cautious when deciding to enter negative interest rate territory, because a low and especially a negative interest rate environment is found to hurt bank stock prices. Controlling for the broad stock market, monetary policy announcements that lower the level of the yield curve and flatten the shorter-end slope of the yield curve have large adverse effects on bank stock prices in a negative interest rate environment. The effects persist in the days after the monetary policy announcements. Banks thus face a specific disadvantage when interest rates are negative. The data on individual bank stock prices suggest this is the result of the lower bound on deposit rates. First, while the relative capitalization of banks does not influence the results in times of negative interest rates, the effects are significantly larger for banks that are relatively dependent on deposit funding. From this perspective, the deposits channel is found to dominate the capital channel of monetary policy when interest rates are negative. Second, the effects are also more persistent for banks that are relatively dependent on deposit funding. Third, a flattening of the longer- rather than the shorter-end of the yield curve does not reduce bank stock prices in times of negative interest rates. Accounting data further substantiate the adverse implications of the zero lower bound on deposit rates, as a parallel drop in the yield curve following monetary policy announcements is found to hurt banks through shrinking deposit margins when interest rates are negative. Together, the results signal that when market interest rates are negative but deposit rates are stuck at zero, monetary policy instruments that target the longer-end of the yield curve are less detrimental to bank performance than those that target the shorter-end. The findings are robust to sample changes and alternative specifications that account for asymmetric and dynamic effects.

The rest of the paper is organized as follows. Section 2 describes the data. Section 3 presents the empirical results. Section 4 concludes.

2. Data

Unanticipated changes (i.e. surprises) in interest rates and stock prices are identified with high-frequency data around 269 ECB monetary policy announcements. The data are from the Euro Area Monetary Policy Event-Study Database by Altavilla et al. (2019) and cover the period from January 1999 to January 2020. This paper considers the beginning of 2009 as the start of the low interest rate environment. At that time, the Deposit Facility Rate (DFR) for banks was cut to 1% and the 1-month Overnight Index Swap (OIS) rate dropped below 1.25%. This is in line with Claessens et al. (2018), who denote the interest rate environment as "low" once risk-free short-term interest rates are below 1.25%. Moreover, rolling regression estimations allow different cutoffs to define a low interest rate environment. June 2014 is considered as the start of the negative interest rate environment. This is when the ECB announced the introduction of a negative interest rate policy by lowering the DFR to −0.1%.[7] In September 2014, when

[7] While the monetary policy announcement took place on June 5, 2014, the measure took effect 6 days later, on June 11, 2014.

Fig. 4. 1-month OIS rate developments.
Notes: This figure shows developments in the 1-month OIS rate for the euro area. The data show that since 2014, the short-term interest rate is negative in the euro area.
Data source: Bloomberg.

the DFR was reduced to −0.2%, the 1-month OIS rate turned negative (Fig. 4). By the end of the sample period, longer-term interest rates also became negative, as indicated by developments in the 10-year German government bond yield (Fig. 1).

The surprises are measured as the difference between the median quote 10 to 20 min before the press release and 10 to 20 min after the press conference, or alternatively, 15 to 25 min after the press release if no press conference took place.[8] The press release is at 13:45, followed by the press conference starting at 14:30 and ending at 15:30. Including the press conference in the monetary event window is essential, as interest rates may react to new information revealed during the Q&A session.

The frequency of ECB monetary policy announcements has changed during the sample. From January 1999 until November 2001, the ECB announced monetary policy decisions twice a month. Every first decision of the month was accompanied by a press conference. Between November 2001 and January 2015, monetary policy announcements occurred on the first Thursday of each month only, generally accompanied by a press conference.[9] Since January 2015, announcements of ECB monetary policy decisions take place every 6 weeks on Thursdays.[10]

The measures of the interest rate surprises are the intraday changes in the 1-month OIS rate, the difference between the 5-year German government bond and 1-month OIS rate, and the difference between the 10- and 5-year German government bond rate. Ceteris paribus, these measures are respectively categorized as changes in the level, shorter-end slope and longer-end slope of the yield curve (also in the remainder of this study).[11] The correlations between the surprises to the level and shorter-end slope of the yield curve, the level and longer-end slope of the yield curve, and the shorter- and longer-end slopes of the yield curve are −0.6, −0.4 and −0.2. Fig. 5 plots the yield curve surprises around the monetary policy decisions. While longer OIS rates are considered a better proxy for identifying the risk-free yield curve, high-frequency data on the 5- and 10-year OIS rates are only available from, respectively, August and July 2011. By way of alternative, German government bond rates are used, as they generally do not comprise a credit risk premium. While Schlepper et al. (2017) show that German government bond rates have incorporated a small scarcity premium since the implementation of the Asset Purchase Programme (APP) in 2015, this endogeneity issue is likely to be negligible since the surprises are intraday. Moreover, the correlation between movements in the slopes of OIS and German yield curves is above 0.9. Consistently, a separate robustness check shows the results are similar when the German rates are substituted with 5- and 10-year OIS rates for the period after August 2011.

Further to the interest rate surprises, announcements related to (Targeted) Longer-Term Refinancing Operations ((T)LTROs) are controlled for, because they provide banks with certainty over attractive funding, which enhances their performance relative to the broad market.[12] The analysis controls for (T)LTROs using a single dummy variable that is equal to 1 on all days of an announcement and 0 otherwise, thereby capturing a common factor on all (T)LTRO announcement days.[13] The (T)LTRO dummy is excluded as a control variable in separate robustness checks.

The measures of the stock price responses are the intraday changes in the logs of the European bank stock index (SX7E) and broad stock market index (STOXX50E). The SX7E and STOXX50E are capitalization-weighted indices that track the stock prices of 24 large banking groups,

[8] Measurement outcomes of the surprises are relatively insensitive to changes in the measurement windows (Altavilla et al., 2019).

[9] Exceptions are provided by Ehrmann and Fratzscher (2009).

[10] Altavilla et al. (2019) summarize the details.

[11] Despite deposits' average duration of 2 years, the end of the shorter-end slope of the yield curve is set at the 5-year interest rate. This is to account for the deposits with a duration longer than 2 years, which generally are matched with replicating asset portfolios of a similar duration; a drop in the 2- to 5-year interest rates is then still expected to reduce deposit margins in a low rate environment.

[12] At the bank-level, the actual amount borrowed under the (T)LTROs is not controlled for, since this information is not publicly available and thus does not influence bank stock prices during the monetary policy announcements.

[13] This paper does not include a set of dummies for each (T)LTRO announcement, since this would effectively exclude those observations from the regression analysis, losing valuable information. For example, on 5 June 2014, when the implementation of TLTROs was first launched, the Eurosystem also introduced its negative interest rate policy by lowering the DFR from 0% to −0.1% for the first time.

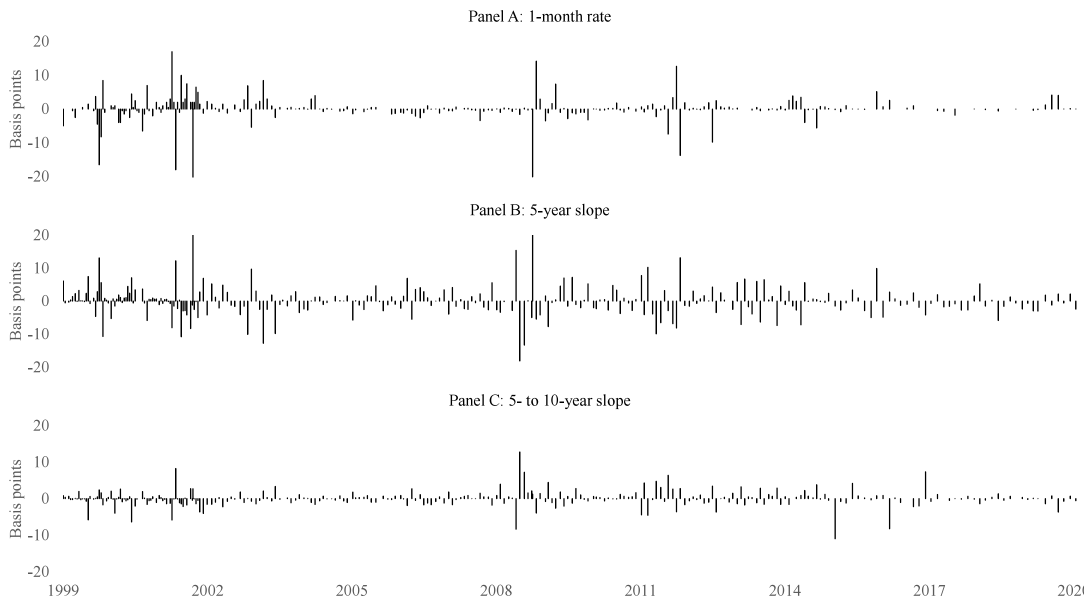

Fig. 5. Interest rate surprises around monetary policy decisions.
Notes: This figure shows interest rate surprises around every monetary policy decision between January 1999 and January 2020. The surprises measure intraday changes in the 1-month OIS rate (Panel A), the difference between the 5-year German government bond rate and the 1-month OIS rate (Panel B), and the difference between the 10-year and 5-year German government bonds rate (Panel C). All intraday changes are measured as the difference between the median quote 10 to 20 min before the monetary policy press release and 10 to 20 min after the ECB press conference, or alternatively, 15 to 25 min after the monetary policy press release if no press conference took place.
Data source: Euro Area Monetary Policy Event-Study Database by Altavilla et al. (2019).

and 50 large financial and non-financial corporations in the euro area, respectively.[14] The covariance between the SX7E and STOXX50E relative to the variance of the STOXX50E is considered the equity beta of bank stocks. Table 1 displays the banks included in the SX7E in the last years of the sample period, when the interest rate environment is negative. The last three columns show the average ratios of customer deposits to total assets, and total and Tier 1 capital to total risk-weighted assets during the negative interest rate environment; i.e. between 2014 and 2019.[15] Data on customer deposits include current accounts, demand deposits and time deposits from households and non-bank corporations.[16] Interbank deposits are excluded. The balance sheet data are from the annual reports published by each individual bank. Except for Natixis, the share of customer deposit funding is above 25% for all banks. Fig. 6 plots the price-to-book ratio of the SX7E. The data show that the performance of European banks has deteriorated substantially since the Global Financial Crisis. Compared to the period before 2008, the price-to-book ratio of the SX7E declined by 75%.

Table 2 shows the descriptive statistics of the interest rate and stock price surprises (respectively in basis and percentage points) in times of positive ($r > 0$) and negative ($r < 0$) interest rates.[17] A general observation stands out. The standard deviations of the interest rate surprises other than the surprise to the 5- to 10-year slope are generally lower in the negative than the positive interest rate environment. This suggests that, to some extent, the magnitude of the rate surprises decreases over time as interest rates reach and fall below the zero lower bound. A similar pattern is observed in Fig. 5.

Next to the intraday data, two types of daily stock price data from Bloomberg are analyzed. First, to check the persistence of the effects, daily developments in the SX7E and STOXX50E are studied following the monetary policy announcements. Second, the individual stock prices of the banks presented in Table 1 are examined in combination with their average deposit ratios in order to check the impact of banks' relative dependence on deposit funding; a negative interest rate environment may have more adverse implications for banks that are relatively dependent on deposit funding. These additional series of stock price data cover the period from January 2000 to January 2020 and represent end-of-day index quotes (i.e., after the press conference ending at 15:30).

The analysis also accounts for the impact of banks' total and Tier 1 capital ratios, as Brei et al. (2019) find that especially low capitalized banks shift from interest-generating towards more fee-related and trading activities in response to low interest rates. In addition, motivated by the recent finding that the deposits channel of monetary policy dominates in countries with relatively low deposit rates (Bittner et al., 2020), this paper checks for differences in the effects on stock prices of banks headquartered in low versus high interest rate countries.[18] These are respectively the 12 banks in Austria, Belgium, France, Germany and the Netherlands versus the 12 banks in Ireland, Italy and Spain.

[14] The compositions of the SX7E and STOXX50E are reviewed periodically.

[15] This paper is not interested in the degree of deposit funding relative to loans, since that is a liquidity rather than a funding indicator; wholesale and retail banks may have relatively similar loan-to-deposit ratios, while differing significantly in terms of dependence on deposit funding.

[16] Since not all banks report data on retail deposits in their annual reports, Table 1 presents a broader aggregate of bank deposits. A caveat is that rates on deposits from non-bank corporates are included, which have to a small extent dropped below zero during the sample period, thus potentially preventing deposit margins turning negative in some occasions. While individual balance sheet data exist on the retail deposits of individual bank subsidiaries (e.g. the IBSI database by the ECB), these databases do not include data on all bank subsidiaries of the banking groups in the sample. Using this incomplete data would therefore generate identification issues, since the data on bank stock prices relate to each individual banking group on aggregate (i.e. including all subsidiaries). Given these complications, this paper uses customer deposits from households and non-bank corporations, recognizing this is an approximation of a bank's relative dependence on retail deposits.

[17] The interest rate period is considered positive (negative) before (after) the monetary policy announcement in June 2014, when the DFR was first lowered beneath zero.

[18] However, different from Bittner et al. (2020), the institutions this paper analyzes are generally banking groups that are active internationally across Europe.

Table 1
SX7E banks and their average share of deposit and capital funding.

	Banks	Country	Customer deposit ratio	Total capital ratio	Tier 1 capital ratio
1	ABN AMRO	NL	0.60	0.24	0.18
2	Banco BPM	IT	0.55	0.16	0.13
3	Bank of Ireland	IR	0.62	0.19	0.16
4	Bankinter	ES	0.61	0.13	0.12
5	BAWAG Group	AT	0.66	0.16	0.14
6	BBVA	ES	0.54	0.15	0.13
7	BNP Paribas	FR	0.37	0.14	0.13
8	Caixabank	ES	0.54	0.16	0.13
9	Commerzbank	DE	0.51	0.17	0.14
10	Crédit Agricole	FR	0.34	0.19	0.14
11	Deutsche Bank	DE	0.32	0.17	0.16
12	Erste Bank	AT	0.67	0.18	0.13
13	Finecobank	IT	0.89	0.25	0.25
14	ING Group	NL	0.63	0.18	0.16
15	Intesa	IT	0.39	0.17	0.15
16	KBC Group	BE	0.54	0.20	0.17
17	Mediobanca	IT	0.27	0.16	0.13
18	Natixis	FR	0.11	0.15	0.13
19	Raiffeisen Bank	AT	0.61	0.18	0.14
20	Sabadell	ES	0.63	0.14	0.13
21	Santander	ES	0.50	0.14	0.13
22	Soc. Générale	FR	0.30	0.17	0.14
23	UBI	IT	0.51	0.15	0.12
24	UniCredit	IT	0.53	0.15	0.13

Notes: This table presents the average ratios of customer deposits to assets, and total and Tier 1 capital to risk-weighted assets of 24 European banks between 2014 and 2019. Together, these banks make up the European capitalization-weighted bank stock index (SX7E) during the last years of the sample period.

Table 2
Descriptive statistics of the surprise data.

Variables	Sample period	Obs		Median		Mean		Std Dev		Min		Max	
		$r > 0$	$r < 0$	$r > 0$	$r < 0$	$r > 0$	$r < 0$	$r > 0$	$r < 0$	$r > 0$	$r < 0$	$r > 0$	$r < 0$
SX7E	01.1999–01.2020	221	48	−0.07	0.01	−0.16	−0.04	0.89	1.23	−6.81	−3.13	3.02	3.02
STOXX50E	01.1999–01.2020	221	48	−0.07	0.06	−0.09	0.00	0.60	0.85	−2.77	−3.65	1.83	2.01
1-month rate OIS	01.1999–01.2020	221	48	0.00	0.00	−0.06	0.14	4.44	1.63	−35.00	−5.60	17.00	5.18
5-year slope DE	01.1999–01.2020	221	48	0.00	−0.63	0.07	−0.29	5.23	2.89	−18.15	−5.87	32.20	9.93
5- to 10-year slope DE	01.1999–01.2020	221	48	0.00	0.00	0.05	−0.19	2.15	2.61	−8.35	−11.00	12.80	7.35
5-year slope OIS	08.2011–01.2020	34	48	−1.02	−0.45	−0.81	−0.24	4.35	2.40	−8.00	−4.99	9.25	7.79
5- to 10-year slope OIS	08.2011–01.2020	34	48	0.36	−0.09	0.48	−0.06	2.27	1.61	−5.00	−6.05	8.60	3.71

Notes: This table presents the descriptive statistics of the monetary policy surprises. The first two variables represent the intraday surprises to the bank stock and broad stock market index, respectively. The last five variables are the intraday surprises to the 1-month OIS rate, the difference between the 5-year German government bond rate and the 1-month OIS rate, the difference between the 10- and 5-year German government bond rate, the difference between the 5-year and 1-month OIS rate, and the difference between the 10- and 5-year OIS rate, respectively. The second column shows for which sample period the surprise data are available. The descriptive statistics are shown in times of positive ($r > 0$) and negative ($r < 0$) policy interest rates (DFR) separately. The interest rate period is considered positive (negative) the period before (after) the monetary policy announcement in June 2014. Data source: Euro Area Monetary Policy Event-Study Database by Altavilla et al. (2019).

Fig. 6. Developments in the price-to-book ratio of the SX7E.
Notes: This figure shows developments in the price-to-book ratio of the SX7E and illustrate that the performance of European banks deteriorated markedly after the great financial crisis of 2008.
Data source: The data are from Bloomberg.

Last, to verify that monetary policy surprises to the shorter-end of the yield curve indeed impact the income of banks once the interest rate environment turns negative, quarterly developments in the deposit margin and return on average assets are analyzed using the (Freriks and Kakes, 2021) database. This database includes a comparable panel of 20 out of the 24 SX7E banks, covering the period from Q3 2007 to Q2 2019. The deposit margin is calculated as the weighted average interest rate paid on bank liabilities to households, non-financial and financial corporations, as well as on central bank borrowing such as via the (T)LTROs, minus the respective risk-free rate (see for data sources and further details Annex A in (Freriks and Kakes, 2021)). The panel also includes country-specific macroeconomic data on real GDP growth, HICP inflation and the average CDS-premium for available bank debt securities (indicating credit risk in the banking system), and bank-specific data on the log of total assets (indicating bank size) and the tier 1 capital ratio. The CDS-premium is calculated as the average premium for five-year senior unsecured bank debt.

3. Empirical results

Rolling regression estimations are employed to analyze the effects of monetary policy surprises to the level and slope of the yield curve on the bank stock index and individual bank stock prices in times of positive and negative interest rates. Using a rolling window allows for a quantification of how bank stock prices react over time as interest rates drop and turn negative. The persistence of these monetary policy effects is checked by examining developments in the bank stock prices the days after the monetary policy decisions. Several robustness checks are performed.

3.1. Effects on the bank stock index

To determine the contemporaneous effects on the bank stock index of a parallel shift and flattening of the shorter- and longer-end of the yield curve, rolling estimations are employed on the following baseline regression model:

$$\begin{aligned} \Delta SX7E_d = \ & \alpha + \beta_1 \Delta Rate_d^{1m} + \beta_2 \Delta Slope_d^{5y-1m} \\ & + \beta_3 \Delta Slope_d^{10y-5y} + \beta_4 \Delta STOXX50_d \\ & + \beta_5 (T)LTRO_d + \epsilon_d \end{aligned} \quad (1)$$

where $\Delta SX7E_d$ represents intraday movements in the log of the bank stock index, $\Delta Rate_d^{1m}$ indicates the 1-month rate surprise, $\Delta Slope_d^{5y-1m}$ denotes the surprise to the difference between the 5-year and 1-month interest rate, $\Delta Slope_d^{10y-5y}$ represents the surprise to the difference between the 10- and 5-year interest rates, $\Delta STOXX50_d$ indicates intraday movements in the log of the broad stock market index, $(T)LTRO_d$ is a dummy variable that indicates Eurosystem announcements regarding (T)LTROs, ϵ_d is the error term, and the subscript d denotes one of the 269 days of monetary policy announcements between 1999 and 2020. In a separate robustness check, the first lag of the dependent variable is included on the right-hand side of the equation to control for dynamic effects. The coefficient of the 1-month rate surprise estimates the effect of a level surprise to the yield curve, since movements in the shorter- and longer-end slope of the yield curve are held constant. The estimations are done over fixed windows of 48 observations, such that the last window covers the maximum period from the introduction of the ECB's negative interest rate policy in June 2014 until the most recent date in the sample. The window size thus maximizes the number of observations over the negative interest rate period in the sample. The fixed windows move by 1 observation each time (also in the other rolling estimations of this paper). The size of the estimation window is changed in an additional robustness check. The estimated rolling coefficient of the variable controlling for broad stock market movements can be interpreted as the equity beta of banks.

Figs. 7 and 8 present the estimations for model (1). The dotted lines represent the 90% confidence interval (also in the remainder of this study). Newey–West standard errors robust to heteroscedasticity and autocorrelation up to the third lag are used.[19] The results suggest that in a positive interest rate environment, a level surprise to the yield curve does not impact the bank stock index when movements in the broad stock market are held constant (Fig. 7, Panel A). Investors thus do not foresee that banks face a disadvantage compared to the broad stock market following a surprise to the level of the yield curve in times of positive interest rates. Bank stock index movements are then solely associated with broader stock market movements. Indeed, the estimated rolling coefficient of the broad stock market index is highly significant over the entire sample period (Fig. 8). The effect of a level surprise to the yield curve changes in a low interest rate environment. Once the low interest rate environment enters the sample period, a level surprise starts to significantly impact the bank stock index. During the period of low but positive interest rates, a parallel 10-basis-points drop in the yield curve decreases the bank stock index by around 0.5 percentage points. The magnitude of this effect increases as the interest rate environment turns negative. By the end of the sample period, a parallel 10-basis-points drop in the yield curve decreases the bank stock index by around 2 percentage points. The effect becomes statistically significant after the low interest rate environment enters the sample period.

A broadly similar pattern is identified looking at the rolling effect on the bank stock index of an unanticipated change to the 1-month to 5-year slope of the yield curve (Fig. 7, Panel B). This shorter-end slope surprise has no effect on the bank stock index in times of positive interest rates, but significantly impacts the bank stock index during periods of low and especially negative interest rates, while accounting for banks' equity-beta. Relative to the 1-month rate, and while controlling for the broader stock market, a 10-basis-points drop in the 5-year rate decreases the bank stock index by around 0.5 percentage points in the environment of low but positive interest rates. Once the rate environments turns negative, a negative shorter-end slope surprise of 10 basis points decreases the bank stock index by around 2 percentage points. This effect is statistically significant in the low and negative interest rate environment.

By contrast, the rolling effect on the bank stock index of a surprise to the slope of the longer-end of the yield curve follows a different pattern (Fig. 7, Panel C). While controlling for broad stock market movements, a slope surprise to the 5- to 10-year yield curve affects the bank stock index when the interest rate environment is low but positive. Relative to the 5-year rate, a drop in the 10-year rate of 10 basis points decreases the bank stock index by around 1 percentage point, statistically significant in the estimation windows covering 2007 to 2012. However, when the interest rate environment turns negative at the end of the sample period, the effect on the bank stock index of a slope surprise to the longer-end of the yield disappears both economically and statistically. Together, the findings suggest that monetary policy measures that target the longer-end slope of the yield curve, such as quantitative easing policies, are less detrimental to the performance of banks relative to the broader market than those that target the shorter-end of the yield curve. This conclusion is consistent with the consideration that, in a negative rate environment, the performance of banks is more adversely impacted by negative surprises to short-term interest rates than the performance of the broader market due to the zero lower bound on bank deposit rates.

As stock market prices may react differently to positive versus negative surprises to the yield curve, the extent of asymmetric effects is analyzed in an additional robustness check. To check for asymmetry

[19] The standard errors change only marginally when excluding the correction for autocorrelation.

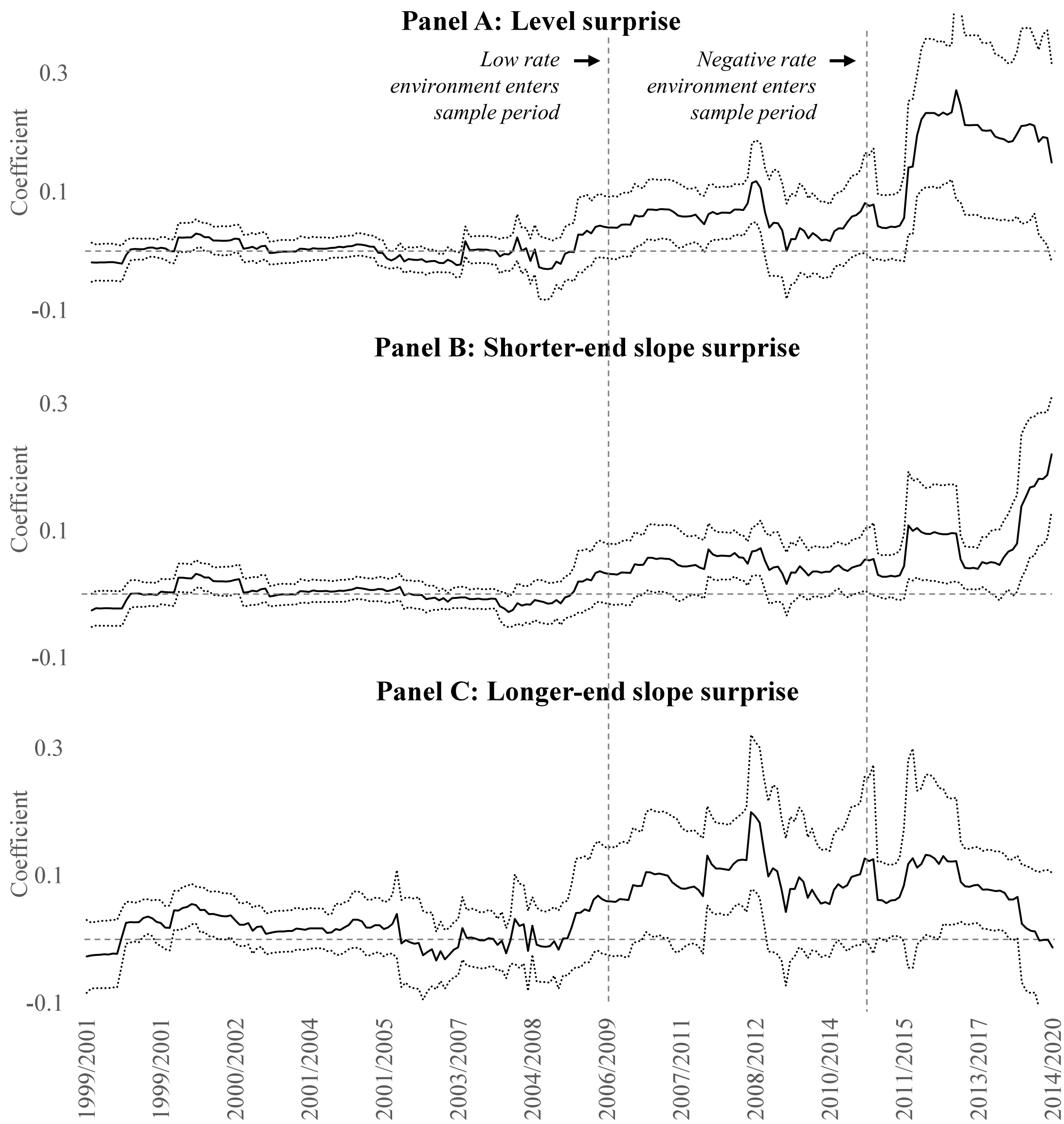

Fig. 7. Effects of monetary policy on the bank stock index at announcement.
Notes: This figure shows the rolling estimations for model (1). The estimations are run over fixed windows of 48 observations, such that the last window covers the maximum period from the introduction of the ECB's negative interest rate policy in June 2014 until the most recent available date in the sample. As monetary Eurosystem meetings occur less frequently over time, the fixed window period widens. The dependent variable measures intraday movements in the log of the bank stock index (SX7E). Panel A shows the rolling effect of a level surprise to the yield curve. Panel B shows the rolling effect of a surprise to the difference between the 5-year and 1-month rate. Panel C shows the rolling effect of a surprise to the difference between the 10- and 5-year rate. Intraday movements in the log of the broad stock market index (STOXX50) and (T)LTRO announcements are controlled for. The dotted lines represent the 90% confidence interval using Newey–West standard errors robust to heteroscedasticity and autocorrelation up to the third lag.

in the effects, rolling estimations are performed using an augmented version of model (1):

$$\begin{aligned}\Delta SX7E_d = \ & \alpha + \beta_{1,positive}(\Delta Rate_d^{1m} * Positive_d^{1m}) \\ & + \beta_{1,negative}(\Delta Rate_d^{1m} * Negative_d^{1m}) \\ & + \beta_{2,positive}(\Delta Slope_d^{5y-1m} * Positive_d^{5y-1m}) \\ & + \beta_{2,negative}(\Delta Slope_d^{5y-1m} * Negative_d^{5y-1m}) \\ & + \beta_{3,positive}(\Delta Slope_d^{10y-5y} * Positive_d^{10y-5y}) \\ & + \beta_{3,negative}(\Delta Slope_d^{10y-5y} * Negative_d^{10y-5y}) \\ & + \beta_4 \Delta STOXX50_d + \beta_5 (T)LTRO_d + \epsilon_d\end{aligned} \tag{2}$$

where $positive_t^{1m}$, $positive_t^{5y-1m}$, $positive_t^{10y-5y}$ and $negative_t^{1m}$, $negative_t^{5y-1m}$, $negative_t^{10y-5y}$ represent dummies that respectively indicate whether the surprises are positive or negative. The rolling Z-test is used to test the significance of the difference between the coefficient estimates for positive and negative surprises. Fig. 9 presents rolling estimations using model (2). The results indicate that the pattern of the rolling effects of a level and shorter-end slope surprise look relatively similar for positive and negative surprises. Both a positive and negative surprise to the level and shorter-end slope of the yield curve have relatively similar significant effects on bank stock prices once the interest rate environment turns negative (Fig. 9, Panels A and B). The rolling Z-test confirms that these effects are not statistically different from each other in times of negative interest rates. This is in line with the results of Altavilla et al. (2019) who find no evidence for asymmetric responses of European financial market variables to positive and negative surprises. However, when the interest rate environment is negative, asymmetry is observed in the effects of longer-end slope surprises on the bank stock index. While negative surprises have no significant effects, the bank stock index reacts significantly to a positive longer-end slope surprise (Fig. 9, Panel C). The difference between these two effects is statistically

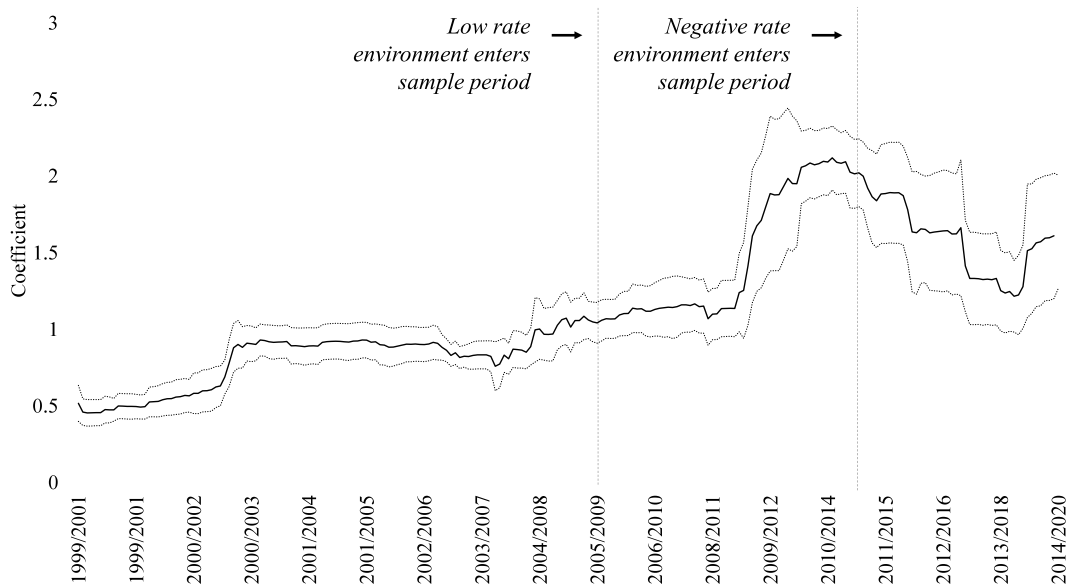

Fig. 8. Effect of the broad stock market on the bank stock index at announcement.
Notes: This figure shows the rolling effect of the broad stock market index on the bank stock index, which can be interpreted as the equity beta of banks, represented by β_4 in model (1). See also the Notes to Fig. 7.

significant in times of negative interest rates. This asymmetry indicates that while bank stocks may benefit from positive longer-end slope surprises, the stock performance of banks relative to the broader market is unaffected by a flattening of the longer-end slope of the yield curve in times of negative interest rates.

To determine the persistence of the effects the days after the monetary policy announcements, rolling estimations are run on model (3) using daily data:

$$\begin{aligned} SX7E_{t+h} - SX7E_{t-1} &= \alpha_h + \beta_{1,h}\Delta Rate_t^{1m} \\ &+ \beta_{2,h}\Delta Slope_t^{5y-1m} + \beta_{3,h}\Delta Slope_t^{10y-5y} \\ &+ \beta_{4,h}(STOXX50_{t+h} - STOXX50_{t-1}) + \beta_{5,h}(T)LTRO_t + \epsilon_{t+h} \end{aligned} \tag{3}$$

for $h = 1$ and 4, where $SX7E_{t+h} - SX7E_{t-1}$ and $STOXX50_{t+h} - STOXX50_{t-1}$ respectively indicate end-of-day changes in the log of the bank stock and broad stock market index, and the subscript h denotes the forecast horizon. The estimations are run over fixed windows of 1461 observations, such that the last window covers the maximum period from the introduction of the ECB's negative interest rate policy in June 2014 until the most recent available date in the sample. The forecast horizon length is changed in a separate robustness check (also using models (4), (5) and (6) of this paper). Model (3) is an extension of the local projections by Jordà (2005). Different from local projections, model (3) controls for contemporaneous broad stock market movements at each forecast horizon. As such, model (3) (as well as models (5) and (6)) assesses whether the impact of surprises to the yield curve on the abnormal return of bank stocks relative to the broader market continues to persist after the monetary policy announcement. Accounting for contemporaneous broad stock market movements is considered central in identifying monetary policy effects on bank stock prices as a result of shrinking deposit margins, since changes in the persistence of the signaling effect of monetary policy, and of its impact on future discount rates and equity risk premiums more generally, need to be controlled for.[20]

Figs. 10 and 11 present the estimations using model (3), showing the cumulative effects when the forecast horizon is 1 and 4 days, respectively. Together with the effects at announcement, the estimations analyze the persistence of the effects over an entire working week. Newey–West standard errors robust to heteroscedasticity and autocorrelation up to the ninth lag are used.[21] The results suggest that in a negative interest rate environment, the effects on the bank stock index of a surprise to the level and shorter-end slope of the yield curve are persistent. When the interest rate environment is low but positive, the effects are not persistent.

On the first day after the announcement, the effects of a level and shorter-end slope surprise on the bank stock index are economically and statistically significant during the negative interest rate period (Fig. 10, Panel A). When the interest rate environment is negative, a parallel downward yield curve shift of 10 basis points significantly decreases the bank stock index by more than 2 percentage points the next day. In times of low but positive interest rates, the effect of a level surprise on the bank stock index is insignificant the day after the announcement. Similarly, the first day after the announcement, a 10-basis-points drop in the 5-year rate relative to the 1-month rate decreases the bank stock index by 2.5 percentage points when the rate environment is negative (Fig. 10, Panel B). This effect is significant at the 1% level in the last estimation windows. In a low but positive interest rate environment, the effect of a longer-end slope surprise is also found to significantly

[20] Controlling for variables that are dated after the surprise variables is not new to the literature on local projections. For example, Teulings and Zubanov (2014) show that including control variables that are dated within the forecast horizon (i.e. between t and t+h) corrects for a downward bias in the estimations of impulse responses using local projections.

[21] For the Newey–West standard errors, this paper chooses longer lags for model (3) than model (1), since model (3) is estimated over larger estimation windows due to the use of daily data.

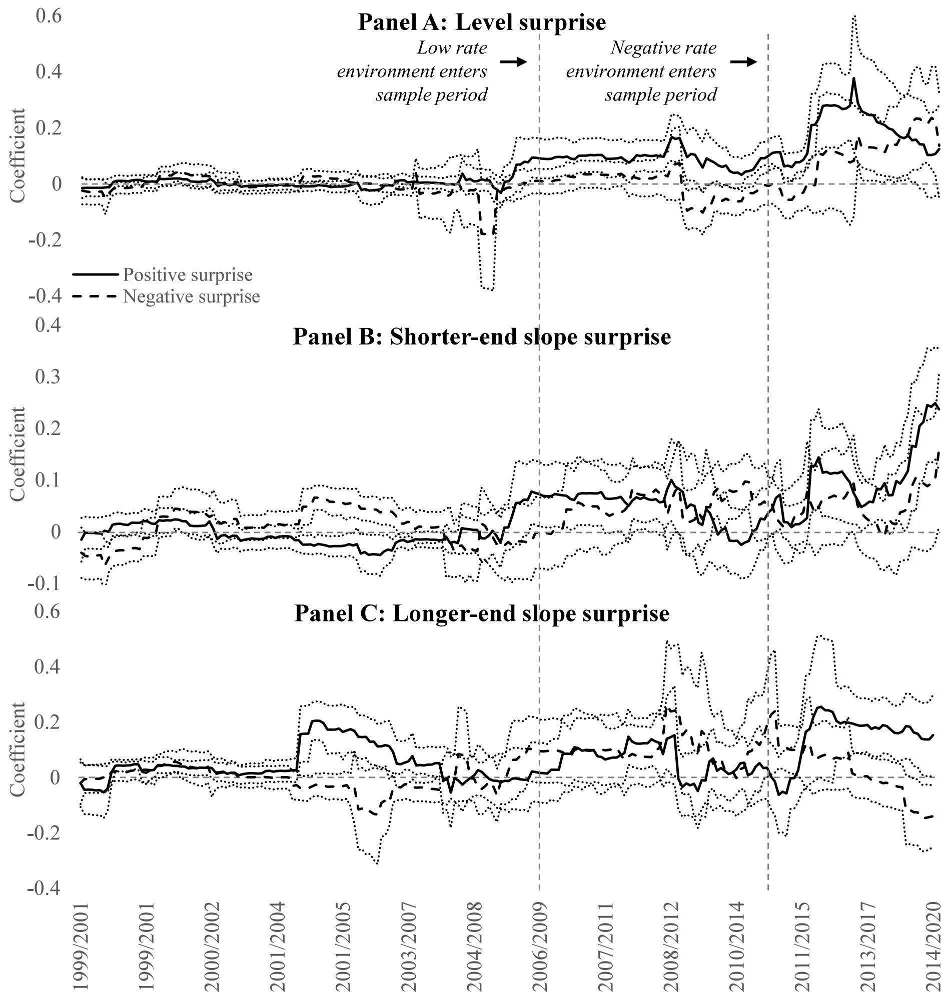

Fig. 9. Asymmetric monetary policy effects on the bank stock index at announcement.
Notes: This figure shows the rolling estimations for model (2). Panel A shows the rolling effect of a positive and negative level surprise to the yield curve. Panel B shows the rolling effect of a positive and negative surprise to the difference between the 5-year and 1-month rate. Panel C shows the rolling effect of a positive and negative surprise to the difference between the 10- and 5-year rate. See also the Notes to Fig. 7.

persist the first day after the announcement, but this effect disappears and becomes insignificant once interest rates turn negative (Fig. 10, Panel C).

While reversing to some degree, the effects of a level and shorter-end slope surprise on the bank stock index persist the fourth day after the announcement in a negative interest rate environment. When the interest rate environment is negative, a parallel downward yield curve shift of 10 basis points decreases the bank stock index by around 1 percentage point the fourth day after the announcement. This is about half the size of the announcement effect. These local projections are only significant at the 10% level in a few estimation windows however (Fig. 11, Panel A). In times of low but positive interest rates, the effect of a level surprise remains insignificant. The effect of a shorter-end slope surprise on the bank stock index is significantly positive the fourth day after the announcement in all estimation windows during the negative interest rate period. Economically, the bank stock index remains 2 percentage points lower the fourth day after a 10-basis-points drop in the 5-year rate relative to the 1-month rate (Fig. 11, Panel B). By contrast, the fourth day after the announcement in a low but positive interest rate environment, a shorter-end slope surprise no longer affects the bank stock index. Similar to previous estimations, the effect of a longer-end slope surprise on the bank stock index remains insignificant the fourth day after the announcement (Fig. 11, Panel C). Substituting the German government bond rates with longer-term OIS rates does not change the persistence of the effects (available upon request).

The previous results suggest that banks face a disadvantage following monetary policy announcements that change the level and shorter-end slope of the yield curve in a negative interest rate environment. However, Fig. 8 shows that the sensitivity of bank stocks to the broader stock market index rises considerably once interest rates become low, which may in part be the result of monetary policy effects. Moreover, the poor performance of banks in times of negative interest rates may also have an impact on the performance of the broader stock market. To validate that the results are not driven by any impact of monetary policy on the equity beta of banks, or on the broader market as a result of the poor bank performance when interest rates are negative, this paper also estimates the effects of the monetary policy surprises on the idiosyncratic return of the bank stock index using end-of-day data (including days on which no monetary policy decision was

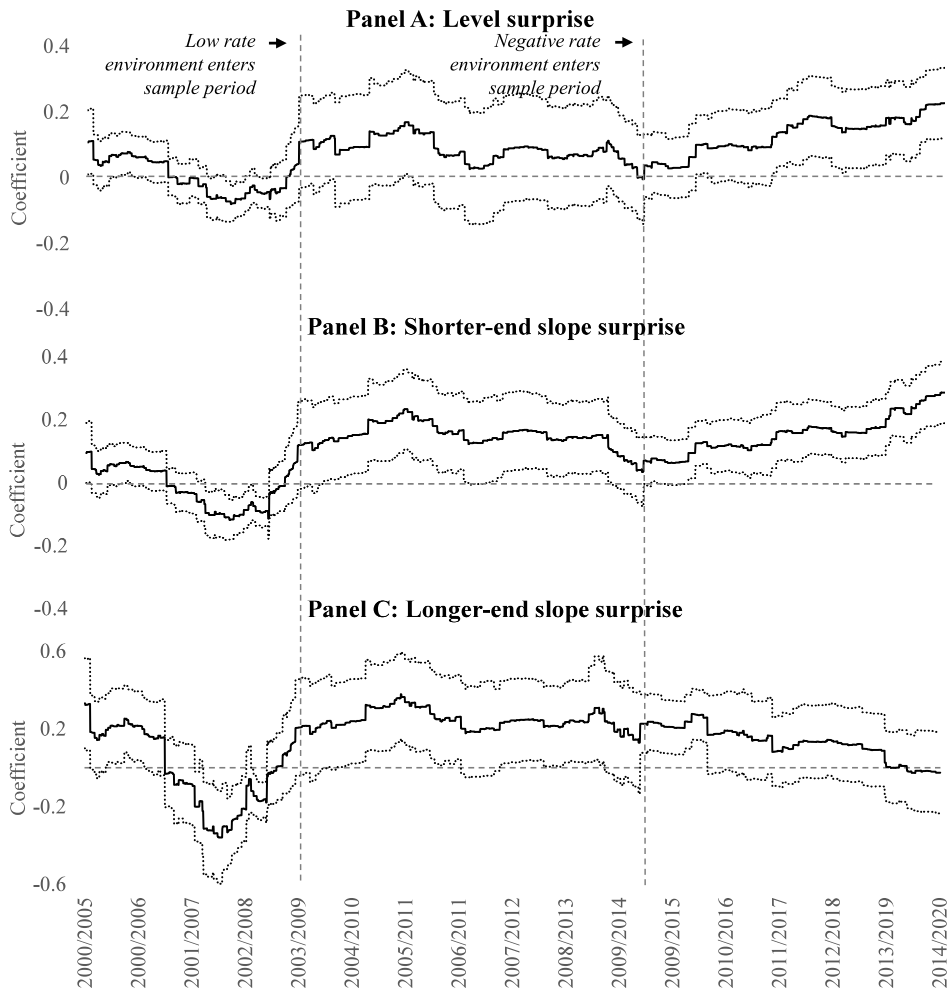

Fig. 10. Cumulative effects on the bank stock index 1 day after announcement.
Notes: This figure shows the rolling local projections for model (3) when the forecast horizon is 1 day. The estimations are run over fixed windows of 1461 observations, such that the last window covers the maximum period from the introduction of the ECB's negative interest rate policy in June 2014 until the most recent available date in the sample. The dependent variable measures end-of-day movements in the log of the bank stock index (SX7E). End-of-day movements in the log of the broad stock market index (STOXX50) and (T)LTRO announcements are controlled for. Newey–West standard errors robust to heteroscedasticity and autocorrelation up to the ninth lag are used. See also the Notes to Fig. 7.

announced, similar to the data for the estimation of model (3)).[22] These estimations are done in two steps. First, using a Capital Asset Pricing Model (CAPM) specification, the idiosyncratic return is constructed as the daily residual from a rolling regression of daily log changes in the bank stock index on daily log changes in the broad stock market index. The residuals are taken from rolling regressions, so as to allow for changes in the CAPM beta of the bank stock index over time. Fig. A.1 in Appendix shows that, similar to the estimated time series of the equity beta in Fig. 8 using model (1), the CAPM beta also increases over time, although with less volatility, which can be explained by the larger rolling windows when estimating the CAPM beta using daily data. Similar to model (3), these rolling regressions are run over fixed windows of 1461 observations, such that the last window covers the maximum period of negative interest rates. Second, using the daily residual, the following model is estimated:

$$
\begin{aligned}
\sum_{h=0}^{H} Residual_{t+h} = \; & \alpha_h + \beta_{1,high,h}(\Delta Rate_t^{1m} * High_t) \\
& + \beta_{1,low,h}(\Delta Rate_t^{1m} * Low_t) \\
& + \beta_{1,negative,h}(\Delta Rate_t^{1m} * Negative_t) \\
& + \beta_{2,high,h}(\Delta Slope_t^{5y-1m} * High_t) \\
& + \beta_{2,low,h}(\Delta Slope_t^{5y-1m} * Low_t) \\
& + \beta_{2,negative,h}(\Delta Slope_t^{5y-1m} * Negative_t) \\
& + \beta_{3,high,h}(\Delta Slope_t^{10y-5y} * High_t) \\
& + \beta_{3,low,h}(\Delta Slope_t^{10y-5y} * Low_t) \\
& + \beta_{3,negative,h}(\Delta Slope_t^{10y-5y} * Negative_t) \\
& + \beta_{4,h}(T)LTRO_t + \epsilon_{t+h}
\end{aligned}
\tag{4}
$$

[22] In addition, to facilitate the interpretation of the baseline findings, this paper also reports the results of the broad stock market reaction to the monetary policy surprises (see Table A.1 in Appendix).

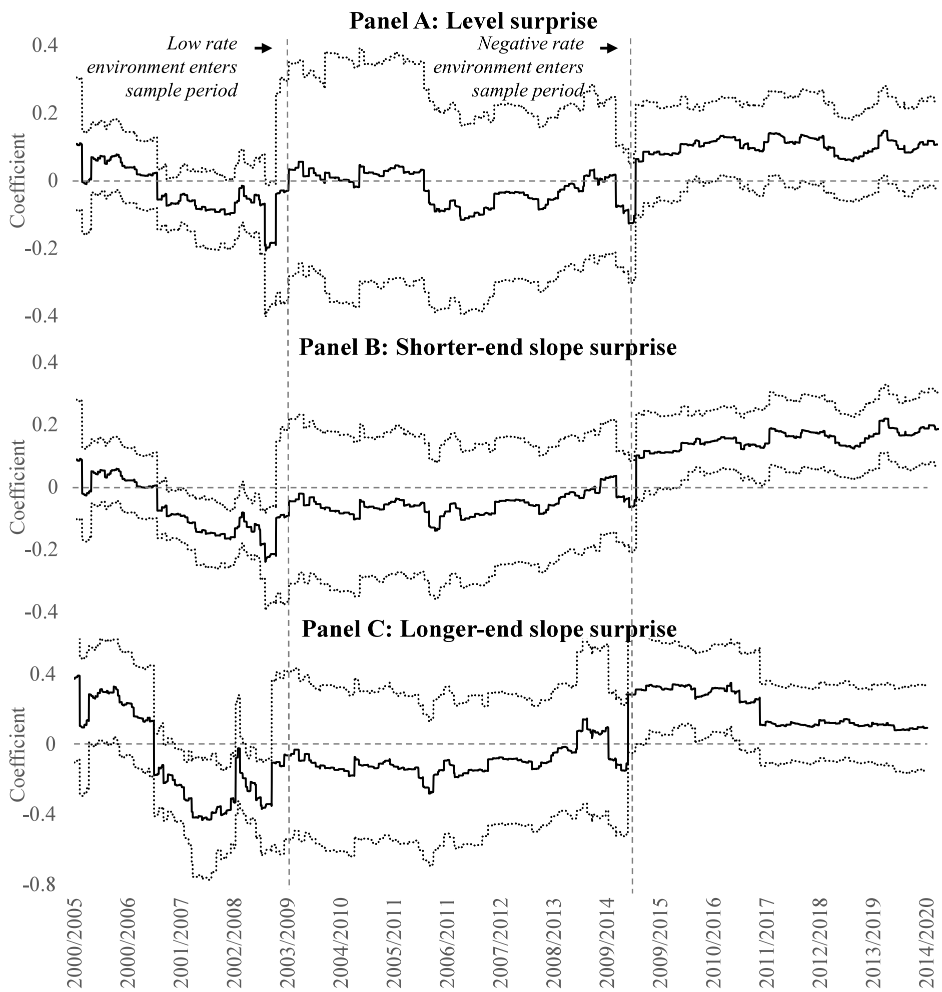

Fig. 11. Cumulative effects on the bank stock index 4 days after announcement.
Notes: This figure shows the rolling local projections for model (3) when the forecast horizon is 4 days. See also the Notes to Fig. 10.

for $H = 0$, 1 and 4, where $\sum_{h=0}^{H} Residual_{t+h}$ represents the sum of the end-of-day idiosyncratic return of the bank stock index, $Rate_t^{1m}$, $Slope_t^{5y-1m}$ and $Slope_t^{10y-5y}$ are the monetary policy surprises to the yield curve on the days of announcement and zero otherwise, $High_t$, Low_t and $Negative_t$ represent dummies that indicate the high, low and negative interest rate environments as identified in Section 2, and the subscript t denotes the daily time period. In contrast to model (3), model (4) is based on the local projections by Jordà (2005), since the right-hand side includes only variables that are dated on the day of the monetary policy surprise. When the forecast horizon is larger than 0, $\sum_{h=0}^{H} Residual_{t+h}$ sums every day's residual, such that the cumulative idiosyncratic return since the monetary policy decision is accounted for.

Table 3 presents the estimations for model (4). Newey–West standard errors robust to heteroscedasticity and autocorrelation up to the ninth lag are included in parentheses. The results show that monetary policy surprises to the level and shorter-end slope of the yield curve persistently impact the idiosyncratic return of the bank stock index once the interest rate environment turns negative. At the monetary policy announcement, the idiosyncratic return of the bank stock index decreases by 1.7 and 1.9 percentage points following a parallel drop of 10 basis points in the entire yield curve, and a 10-basis-points drop in the 5-year rate relative to the 1-month rate when interest rates are negative, respectively. Four days after these yield curve surprises, the idiosyncratic return remains 1.5 and 2.1 percentage points lower than before the monetary policy announcement. By contrast, monetary policy announcements that change the longer-end of the yield curve do not significantly impact the idiosyncratic returns of the bank stock index in times of negative interest rates. Together, these results validate the finding that a downward shift in the yield curve and a flattening of the shorter-end of the yield curve resulting from monetary policy announcements hurts bank stock prices in a negative interest rate environment.

Table 3
Effects of monetary policy on the bank stock index's idiosyncratic return.

Regressors	1 at announcement	2 1 day after	3 4 days after
Level surprise * high rate environment	0.01	−0.15*	−0.50
	(0.05)	(0.09)	(0.36)
Level surprise * low rate environment	0.14**	0.13	0.11
	(0.06)	(0.11)	(0.20)
Level surprise * negative rate environment	0.17***	0.26***	0.15*
	(0.03)	(0.06)	(0.08)
Shorter-end slope surprise * high rate environment	−0.01	−0.07	−0.44*
	(0.04)	(0.07)	(0.23)
Shorter-end slope surprise * low rate environment	0.12**	0.15**	0.08
	(0.05)	(0.07)	(0.34)
Shorter-end slope surprise * negative rate environment	0.19***	0.30***	0.21***
	(0.03)	(0.06)	(0.07)
Longer-end slope surprise * high rate environment	0.04	−0.11	−0.69*
	(0.07)	(0.11)	(0.37)
Longer-end slope surprise * low rate environment	0.22*	0.25	0.08
	(0.11)	(0.17)	(0.34)
Longer-end slope surprise * negative rate environment	−0.03	0.03	0.14
	(0.09)	(0.13)	(0.17)
(T)LTRO announcement day	−0.00	−0.00	−0.01*
	(0.00)	(0.01)	(0.01)
N	3,701	3,700	3,697

Notes: This table shows the estimations for model (4). The dependent variable measures the end-of-day idiosyncratic return of the bank stock index, which is calculated as the daily residual from a rolling regression of daily log changes in the bank stock index on daily log changes in the broad stock market index. The rolling regressions are run over fixed windows of 1461 observations. The regressions estimate, in times of high, low and negative interest rates, the effects of monetary policy surprises to the level of the yield curve, the difference between the 5-year and 1-month rate and the difference between the 10- and 5-year rate, respectively. Column 1 shows the impact at announcement. Using local projections, columns 2 and 3 respectively show the impact 1 and 4 days after the announcement. Newey–West standard errors robust to heteroscedasticity and autocorrelation up to the ninth lag are included in parentheses. Constant not shown. Significance levels: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

3.2. Effects on individual bank stock prices

The effects of surprises to the yield curve on the bank stock index may be driven by the largest banks, as the SX7E is capitalization-weighted. Moreover, unobserved differences between banks may influence the results. To determine the average effects of yield curve surprises on individual bank stock prices, rolling fixed effects panel local projections are performed using the following specification:

$$Bank_{i,t+h} - Bank_{i,t-1} = \beta_{1,h}\Delta Rate_t^{1m} + \beta_{2,h}\Delta Slope_t^{5y-1m} + \beta_{3,h}\Delta Slope_t^{10y-5y} + \beta_{4,h}(STOXX50_{t+h} - STOXX50_{t-1}) + \beta_{5,h}(T)LTRO_t + \mu_{i,h} + \epsilon_{i,t+h} \quad (5)$$

for $h = 0$, 1 and 4, where $Bank_{i,t+h} - Bank_{i,t-1}$ indicates end-of-day changes in the log of individual bank stock prices, $\mu_{i,h}$ represents bank fixed effects that capture unobserved differences between banks, and the subscript i denotes each one of the 24 banks captured by the SX7E presented in Table 1. The estimations are also run over fixed windows of 1461 observations.

Figs. 12–14 present the rolling panel local projections using model (5) with bank fixed effects. The figures show the cumulative effects when the forecast horizon is 0, 1 and 4 days, respectively. Robust standard errors clustered across banks and time are used. The results indicate that at announcement, a surprise to the level, shorter-end slope and longer-end slope of the yield curve significantly affects bank stock prices once the low interest rate environment enters the sample period.[23] In times of negative interest rates, the effects of the level and shorter-end slope surprises remain statistically significant, while the effect of a longer-end slope surprise turns insignificant in the last estimation windows.[24] Both a parallel 10-basis-points drop in the yield curve as well as a 10-basis-points drop in the 5-year rate relative to the 1-month rate decreases bank stock prices by around 1.5 percentage points in a low but positive and negative interest rate environment (Fig. 12, Panel A and Panel B). Relative to the 5-year rate, a 10-basis-points drop in the 10-year rate decreases bank stock prices by around 3 percentage points in times of low but positive interest rates (Fig. 12, Panel C). However, as the interest rate environment turns negative, the effect of a longer-end slope surprise on bank stock prices decreases and eventually becomes insignificant.

Turning to the 1- and 4-day projections, the results show the effects of a level and shorter-end slope surprise on individual bank stock prices are persistent when the interest rate environment is negative. In times of low but positive interest rates, individual bank stock prices

[23] These effects may in part also reflect the European banking and sovereign debt crisis. To the extent monetary policy surprises amplify the adverse effects of financial and sovereign debt stress on bank balance sheets, banks may face a disadvantage compared to the broader market. By contrast, as most European financial markets stabilized by the end of 2012, and the post-crisis implementation of the European Banking Union and new macroprudential policies further buttressed the banking sector's resilience, financial and sovereign debt stress are less of an explanation for monetary policy effects in times of negative interest rates.

[24] The bank fixed effects are significantly different from zero in almost all estimation windows (also in the remainder of this paper).

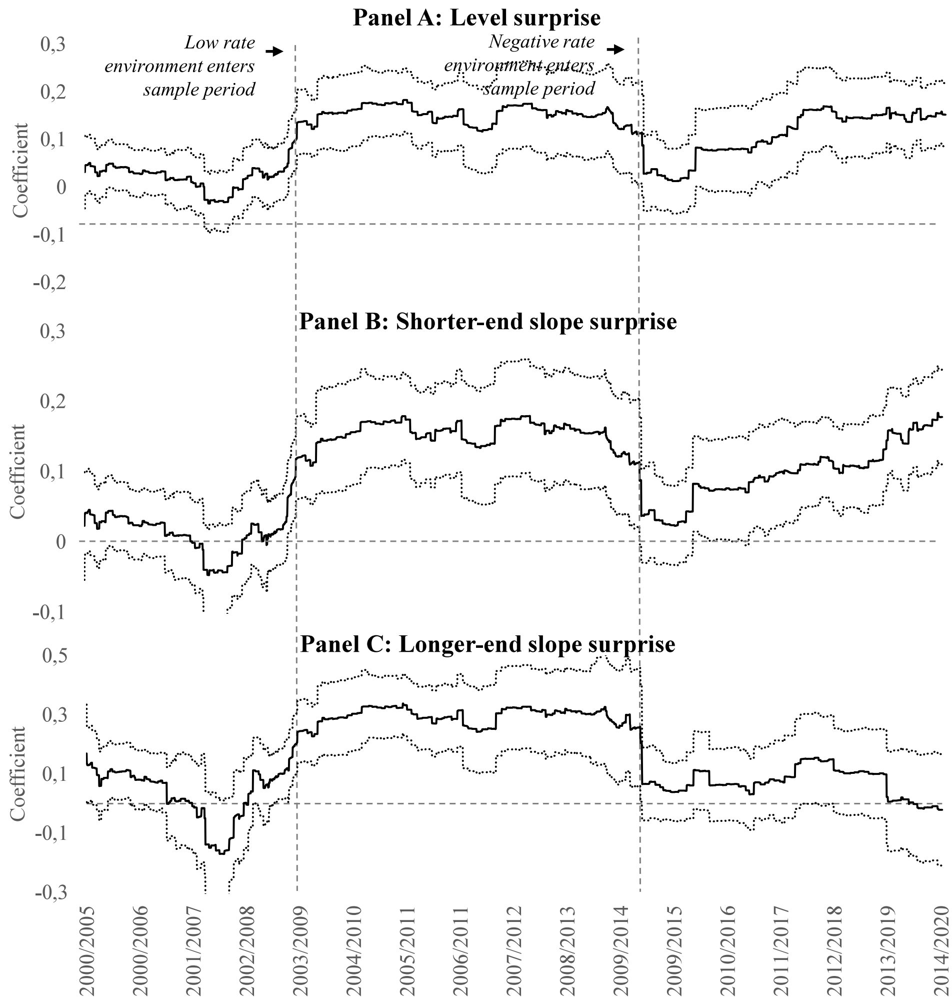

Fig. 12. Monetary policy effects on individual bank stocks at announcement.
Notes: This figure shows the rolling fixed effects estimations for model (5) on the day of the monetary policy announcement. The dependent variable measures end-of-day movements in the log of individual bank stocks. Robust standard errors clustered across banks and time are used. See also the Notes to Fig. 10.

also react significantly to a level and shorter-end slope surprise the day after the announcement. However, the significance of these effects disappears the fourth day after the monetary policy decision. This suggests that the effects of a level and shorter-end slope surprise on bank stock prices are not persistent when interest rates are low but still positive. By contrast, when the interest rate environment is negative, bank stock prices remain 1.5 percentage points lower the first and fourth day after a parallel downward yield curve shift of 10 basis points (Figs. 13 and 14, Panel A). Similarly, in the last estimation windows when the interest rate environment is negative, individual bank stock prices remain 2 to 3 percentage points lower on the first and fourth day after a 10-basis-points drop in the 5-year rate relative to the 1-month rate (Figs. 13 and 14, Panel B). These local projections are significant in all estimation windows after the negative interest rate environment enters the sample period. While bank stock prices also react significantly to longer-end slope surprises the first day after the announcement in a low but positive interest rate environment, this effect becomes insignificant on the fourth day (Figs. 13 and 14, Panel C). In the estimation windows that include the start of the negative interest rate environment, a significant effect is observed the fourth day after a longer-end slope surprise, but this effect decreases both economically and statistically as the interest rate environment turns more negative.

In a separate robustness check, the effects of monetary policy surprises to the yield curve are also estimated on the idiosyncratic returns of the individual bank stock prices, using the approach of CAPM regressions as described in Section 3.1 for each individual bank separately. Fig. A.2 in Appendix shows the dispersion in the individual banks' estimated CAPM beta, which has decreased somewhat over time. Using model (4) at the bank-level, the results indicate that in times of negative interest rates, a drop in the level and flattening of the shorter-end slope of the yield curve reduce the individual banks' idiosyncratic returns, while a flattening of the longer-end slope of the yield curve has no significant impact (Table 4). The effects of changes to the level and shorter-end slope of the yield curve are also found to persist in the days after the announcement, together validating the findings in Figs. 12–14. The only exception is that the effect of a level surprise to the yield curve is no longer statistically significant the fourth day after the monetary policy announcement (but close to statistical significance at the 10% level).

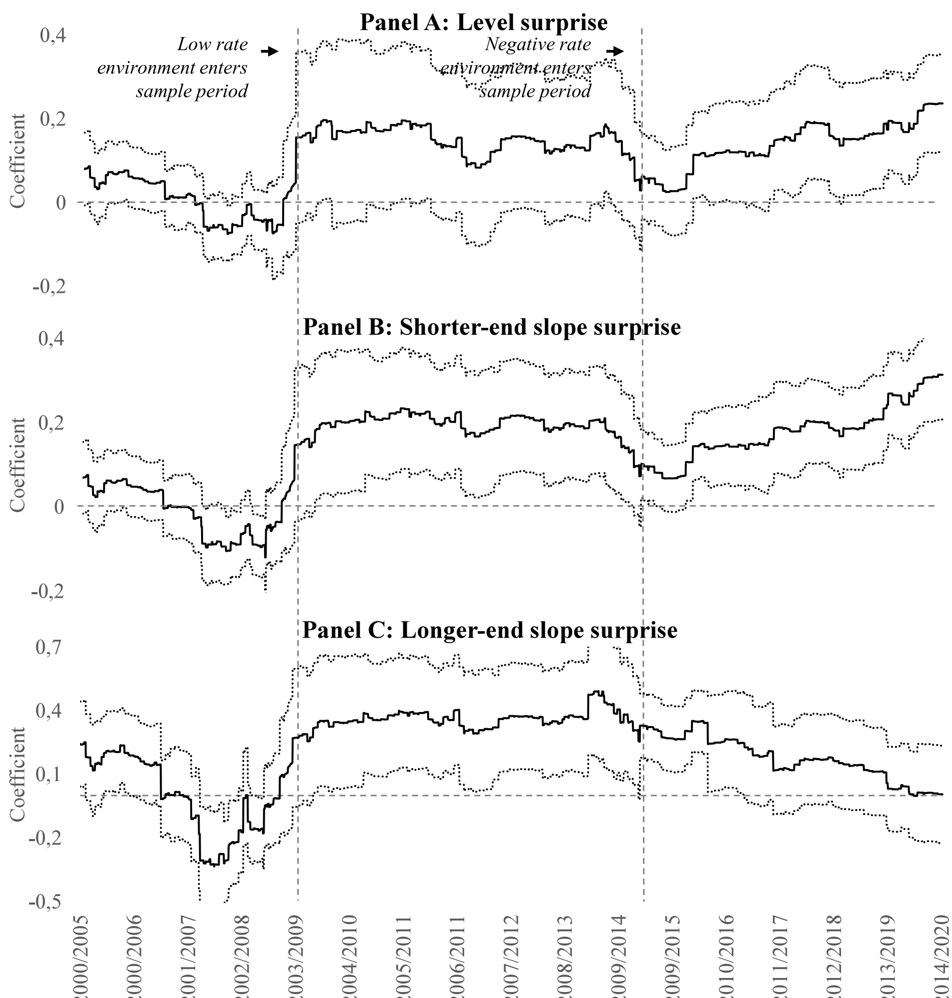

Fig. 13. Cumulative effects on individual bank stocks 1 day after announcement.
Notes: This figure shows the rolling panel local projections for model (5) when the forecast horizon is 1 day. See also the Notes to Fig. 12.

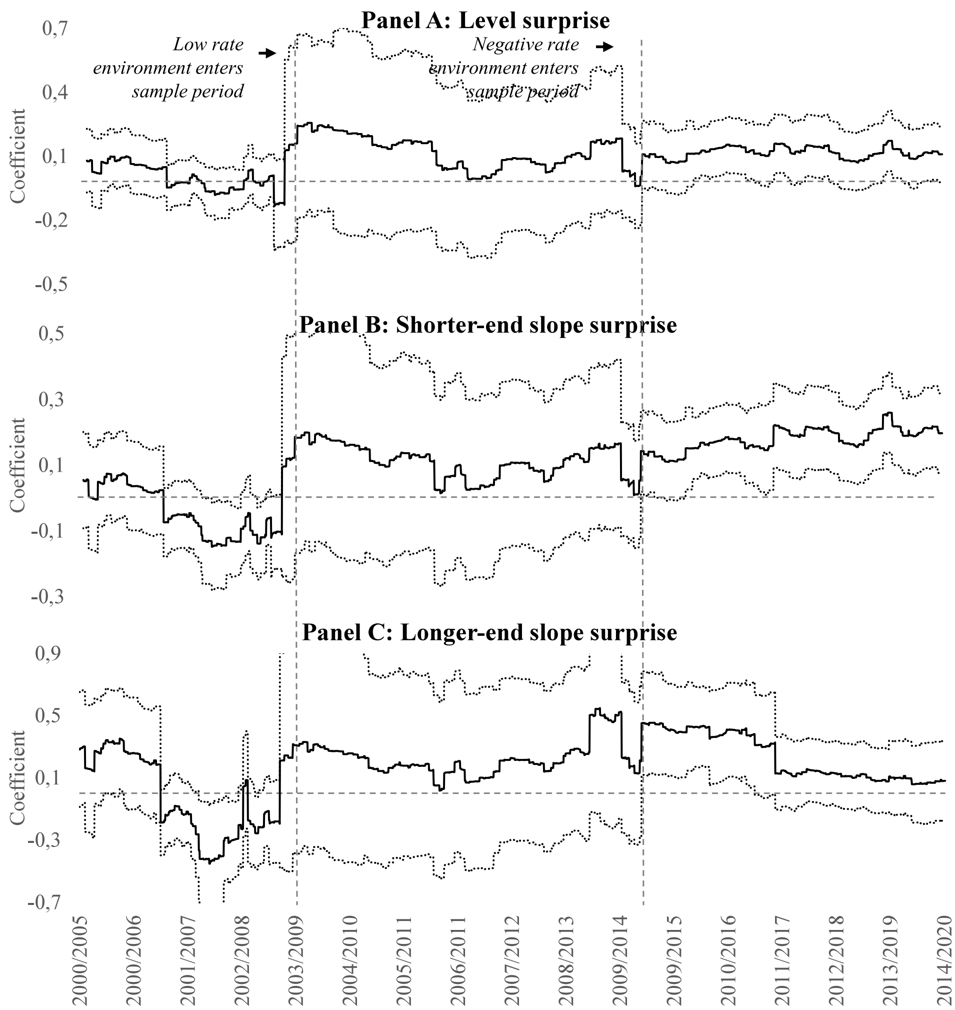

Fig. 14. Cumulative effects on individual bank stocks 4 days after announcement.
Notes: This figure shows the rolling panel local projections for model (5) when the forecast horizon is 4 days. See also the Notes to Fig. 12.

3.3. Effects on stock prices of banks relatively dependent on deposits

In times of low and negative interest rates, yield curve surprises are expected to have larger effects on stock prices of banks that are relatively dependent on deposit funding. This is because the performance of these banks is likely to be more affected by changes to the deposit margin than the performance of banks with a relatively small share of deposit funding. To identify this deposits channel of monetary policy, rolling regressions are estimated using a model that includes interactions between the monetary policy surprises to the yield curve and two dummies that respectively indicate whether a bank has a relatively high or low deposit ratio:

$$\begin{aligned} Bank_{i,t+h} - Bank_{i,t-1} = \ & \beta_{1,high,h}(\Delta Rate_t^{1m} * High_i) \\ & + \beta_{1,low,h}(\Delta Rate_t^{1m} * Low_i) \\ & + \beta_{2,high,h}(\Delta Slope_t^{5y-1m} * High_i) \\ & + \beta_{2,low,h}(\Delta Slope_t^{5y-1m} * Low_i) \\ & + \beta_{3,high,h}(\Delta Slope_t^{10y-5y} * High_i) \\ & + \beta_{3,low,h}(\Delta Slope_t^{10y-5y} * Low_i) \\ & + \beta_{4,h}(STOXX50_{t+h} - STOXX50_{t-1}) \\ & + \beta_{5,h}(T)LTRO_t + \mu_{i,h} + \epsilon_{i,t+h} \end{aligned} \tag{6}$$

for $h = 0$, 1 and 4, and where $High_i$ and Low_i represent dummies that respectively indicate whether, during 2014 and 2019, the average ratio of customer deposits to assets of bank i is higher or lower than the time-invariant sample median. Again, the estimations are run over fixed windows of 1461 observations.

Model (6) analyzes whether, controlling for broad stock market movements, banks with relatively high deposit ratios are impacted more by monetary policy surprises to the yield curve than banks with relatively low deposit ratios. Accordingly, the model imposes the same market beta for all banks. This is important for identification, because it assesses whether individual bank stock price deviations from the average market beta are larger for banks with relatively high versus low deposit ratios. Similarly, this paper does not use CAPM regressions to study the monetary policy effects on the idiosyncratic returns of banks with high versus low deposit ratios, because the CAPM betas may already capture the individual banks' reliance on deposit funding. Indeed, Fig. A.3 in Appendix shows that while in times of positive interest rates the CAPM beta does not relate to the deposit ratio, the correlation between the CAPM betas and deposit ratios is significantly negative in times of negative interest rates. The negative correlation reflects that, relative to the variance of the broad stock market return, the covariance between the broad stock market return and a bank's stock price return is smaller for banks with relatively high deposit

Table 4
Effects of monetary policy on individual bank stocks' idiosyncratic return.

Regressors	1 at announcement	2 1 day after	3 4 days after
Level surprise * high rate environment	−0.01	−0.23*	−0.53
	(0.07)	(0.13)	(0.34)
Level surprise * low rate environment	0.18***	0.24*	0.32
	(0.06)	(0.13)	(0.30)
Level surprise * negative rate environment	0.18***	0.28***	0.15
	(0.04)	(0.07)	(0.09)
Shorter-end slope surprise * high rate environment	−0.02	−0.15	−0.36
	(0.05)	(0.11)	(0.22)
Shorter-end slope surprise * low rate environment	0.17***	0.23**	0.22
	(0.05)	(0.09)	(0.19)
Shorter-end slope surprise * negative rate environment	0.20***	0.33***	0.23**
	(0.04)	(0.07)	(0.08)
Longer-end slope surprise * high rate environment	0.05	−0.20	−0.57
	(0.09)	(0.19)	(0.38)
Longer-end slope surprise * low rate environment	0.33***	0.49**	0.51
	(0.11)	(0.21)	(0.51)
Longer-end slope surprise * negative rate environment	−0.01	0.08	0.15
	(0.10)	(0.16)	(0.19)
(T)LTRO announcement day	−0.00	−0.00	−0.02
	(0.00)	(0.01)	(0.01)
N	70,943	70,262	68,535

Notes: This table shows the estimations for model (4) using bank-level data. The dependent variable measures the end-of-day idiosyncratic return of individual bank stock prices, which is calculated as the daily residual from a rolling regression of daily log changes in the stock price of individual banks on daily log changes in the broad stock market index. Robust standard errors clustered across banks and time are included in parentheses. See also notes to Table 3.

ratios. The smaller covariance in relation to the broader market can be explained by the specific disadvantage deposit-dependent banks face when market interest rates are negative but deposit rates stuck at zero. Interest rate cuts may be associated with both an increase or a decrease in stock market valuations, but following rate cuts in negative territory, banks with high deposit ratios are subject to more adverse stock market revaluations than the broader market due to their squeezed profitability.

Figs. 15–17 display the results. The figures show the cumulative effects when the forecast horizon is 0, 1 and 4 days, respectively. The significance of the difference between the coefficient estimates for banks with relatively high versus low deposit ratios is tested using the rolling Z-test. The results indicate that once the interest rate environment is negative, the effects on stock prices of a level and shorter-end slope surprise are larger for banks relatively dependent on deposit funding. When interest rates are negative, a 10-basis-points parallel shift in the yield curve and flattening of the shorter-end of the yield curve reduce stock prices of deposit-dependent banks by almost 2 percentage points (Fig. 15, Panels A and B). Stock prices of banks that are less dependent on deposit funding only drop by around 1 percentage point in times of negative interest rates. These effects are statistically significant. By contrast, longer-end slope surprises are not found to have different effects on the two types of banks' stock prices in a negative interest rate environment (Fig. 15, Panel C). In this environment, the effects of longer-end slope surprises on bank stock prices are insignificant for both high and low deposit-dependent banks. When interest rates are low but positive, the effects of the yield curve surprises are relatively similar for both groups of banks. Stock prices fall by around 1.5 to 2 percentage points in response to a 10-basis-points parallel drop in the yield curve and flattening of the shorter-end of the yield curve. A downward longer-end slope surprise of 10 basis points reduces stock prices of banks by around 3 percentage points. These effects are statistically significant.

Figs. 16 and 17 show that the effects of a level and shorter-end slope surprise on stock prices of banks more dependent on deposit funding are persistent, especially in times of negative interest rates. In a negative interest rate environment, the first and fourth day after a parallel yield curve shift of 10 basis points or a 10-basis-points drop in the 5-year rate relative to the 1-month rate stock prices of banks with relatively high deposit ratios are lower by approximately 3 percentage points (Figs. 16 and 17, Panel A and Panel B). These local projections are statistically significant when the negative interest rate environment enters the sample. However, when analyzing the stock prices of banks that are less dependent on deposit funding, the local projections look different. The effect of a level surprise on stock prices of deposit-independent banks persists the first day after the announcement, but reverses the fourth day after the announcement. The effects of shorter- and longer-end slope surprises on stock prices of banks relatively independent of deposit funding also disappear the fourth day after the announcement in the low but positive interest rate environment. However, the effect of shorter-end slope surprises persists when the interest rate environment is negative. The fourth day after a 10-basis-points drop in the 5-year rate relative to the 1-month rate, stock prices of banks relatively independent of deposit funding remain 1 percentage point lower in the last estimation windows (Fig. 17, Panel B). This effect is statistically significant, but is less than half the effect on deposit-dependent banks. The rolling Z-test confirms that in case of level and shorter-end slope surprises in times of negative interest rates, the effects on stock prices of relatively deposit-dependent and -independent banks are statistically different from each other at the 10% significance level the fourth day after the announcement. The effects of longer-end slope surprises are not statistically different from each other.

The two dummies in model (6) are also substituted with dummies that respectively indicate whether a bank is relatively capitalized or not (looking at both total and Tier 1 capital ratios), and whether a bank is headquartered in a country with relatively low (i.e. Austria, Belgium, France, Germany or the Netherlands) or high interest rates (Ireland, Italy or Spain). However, the results show that in the negative interest rate period, the effects on stock prices of relatively capitalized

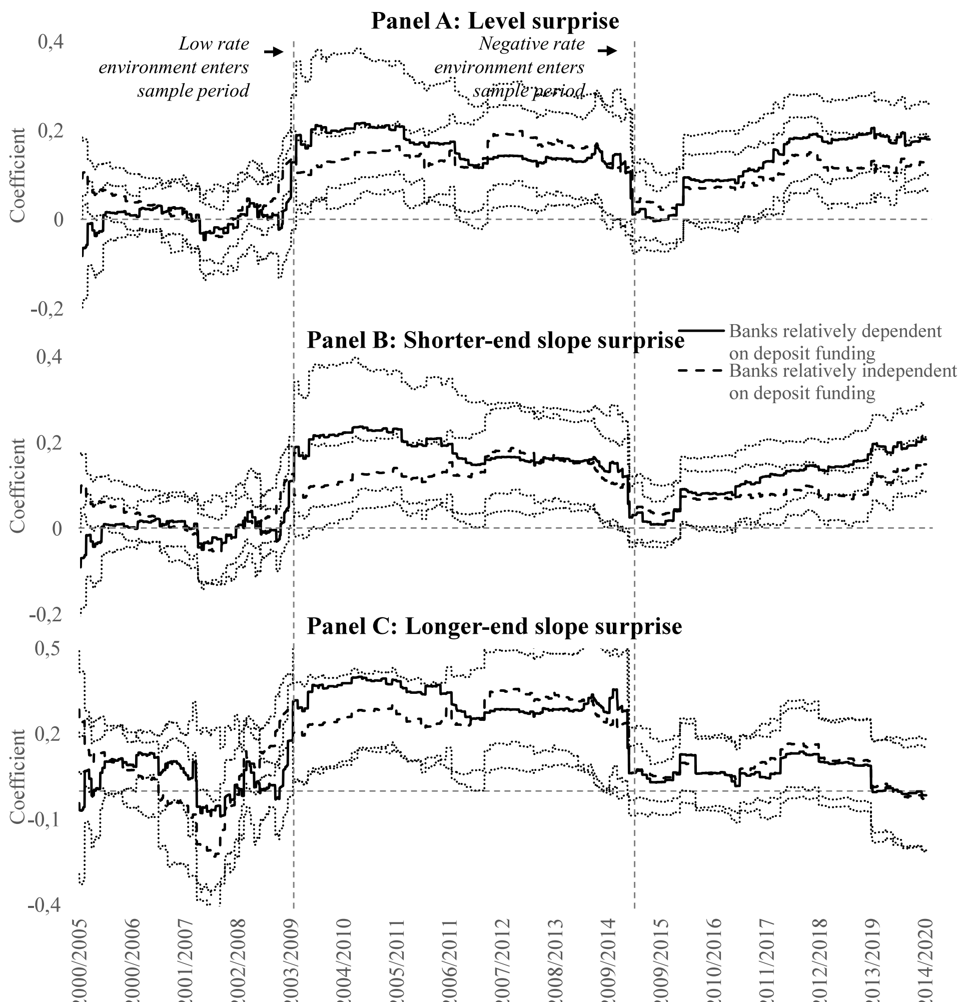

Fig. 15. Monetary policy effects on individual bank stocks at announcement.
Notes: This figure shows the rolling panel estimations for model (6) on the day of the monetary policy announcement for banks with relatively high versus low deposit ratios. See also the Notes to Fig. 12.

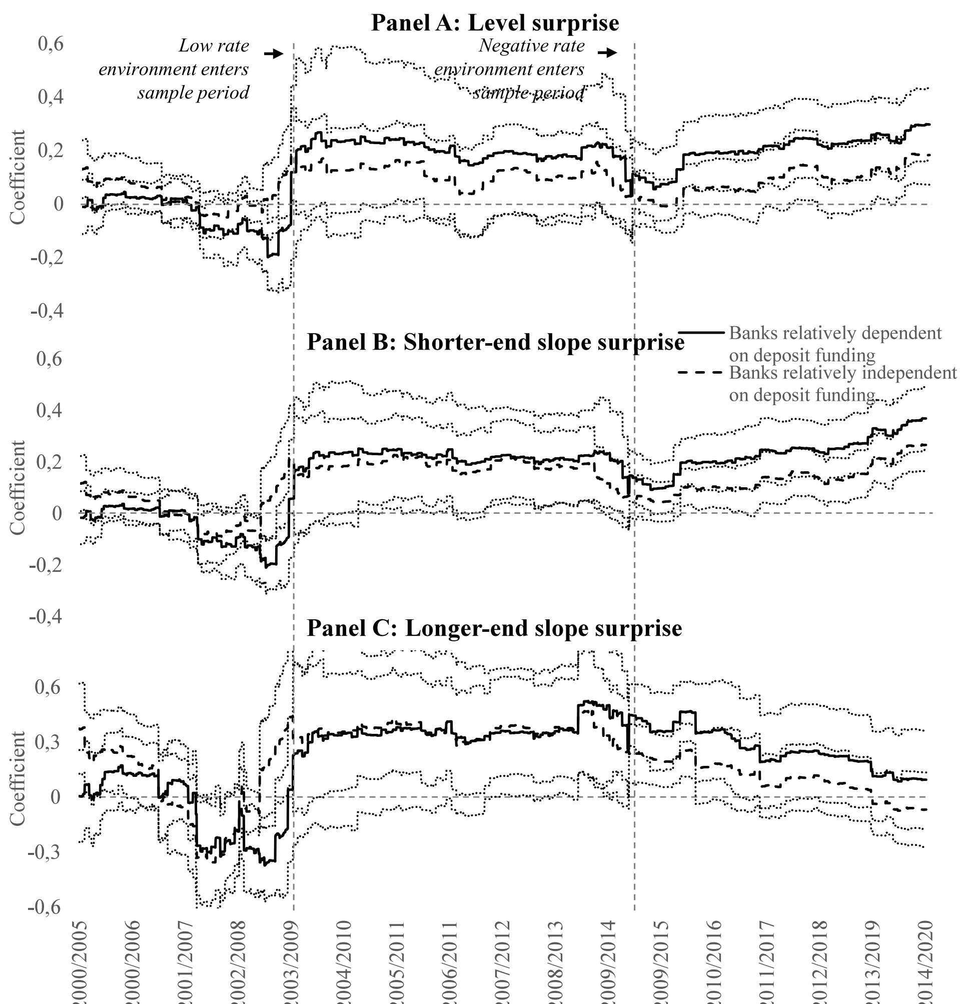

Fig. 16. Cumulative effects on individual bank stocks 1 day after announcement.
Notes: This figure shows the rolling panel local projections for model (6) when the forecast horizon is 1 day. See also the Notes to Fig. 15.

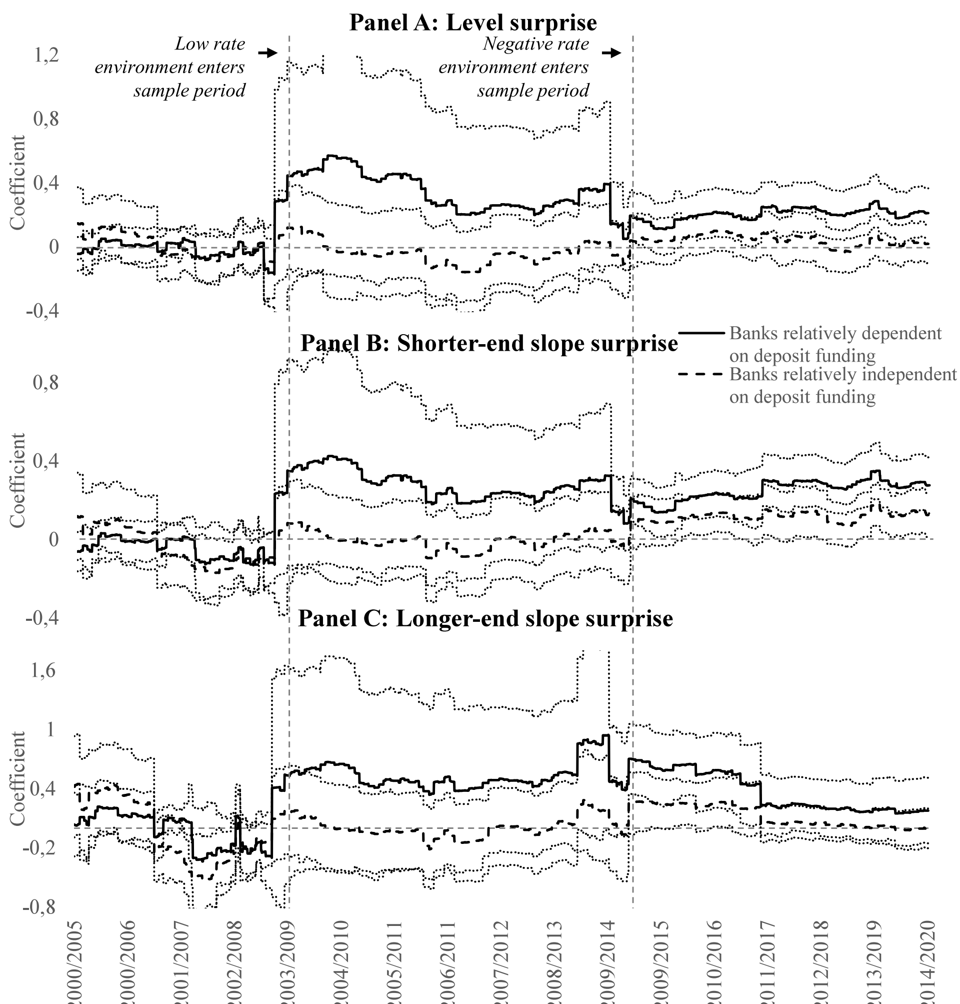

Fig. 17. Cumulative effects on individual bank stocks 4 days after announcement.
Notes: This figure shows the rolling panel local projections for model (6) when the forecast horizon is 4 days. See also the Notes to Fig. 15.

and undercapitalized banks, and of banks headquartered in low and high interest rate countries, are not significantly different from each other (available upon request).

3.4. Effects on bank balance sheet and income statement items

The adverse impact of negative monetary policy surprises on bank stock prices in times of negative interest rates reflects the expectation of poorer bank performance once interest rates are negative. Bank stock prices may drop because investors believe that a negative interest rate environment hurts banks through shrinking deposit margins. To check whether banks' income through deposit margins indeed starts to drop following accommodative monetary policy in a negative interest rate environment, the following model is estimated in times of (1) high, (2) low but positive and (3) negative interest rates:

$$\pi_{i,q} = \beta_1 \pi_{i,q-1} + \beta_2 \Delta Rate_q^{1m} + \beta_3 \Delta Slope_q^{5y-1m} + \beta_4 \Delta Slope_q^{10y-5y} + \beta_5' X_q + \beta_6' Z_{i,q} + \mu_i + \epsilon_{i,q} \quad (7)$$

where $\pi_{i,q}$ is a vector including the deposit margin and return on average assets, $Rate_q^{1m}$, $Slope_q^{5y-1m}$ and $Slope_q^{10y-5y}$ are changes (in basis points) in the quarterly average of the 1-month interest rate, the difference between the 5-year and 1-month interest rates and the difference between the 10- and 5-year interest rates, respectively, X_q is a vector of country-specific macroeconomic control variables, including the real GDP growth, HICP inflation and CDS-premium for bank debt securities, $Z_{i,q}$ is a vector of bank-specific control variables, including the log of total assets and Tier 1 capital ratio, and the subscripts i and q denote the bank and the quarterly time period, respectively.

The use of quarterly data complicates the identification of monetary policy effects, since the surprises are identified with high-frequency data and only occur around irregularly announced monetary policy decisions. To tackle this issue, and approximate the impact of monetary policy on the deposit margin and return on assets, this paper uses the fixed effects instrumental variables (IV) estimator, following the approach by Mark and Karadi (2015) and English et al. (2018). More specifically, the quarterly-averages of the monetary policy surprises to the yield curve are used as external instruments for $Rate_q^{1m}$, $Slope_q^{5y-1m}$ and $Slope_q^{10y-5y}$.

Table 5 presents the estimations for model (7). Robust standard errors clustered across banks and time are used. Each set of three columns shows the impact of the monetary policy surprises on the deposit margin and return on assets in times of high, low but positive and negative interest rates, respectively. The results indicate that a monetary policy surprise to the level of the yield curve impacts the deposit margin significantly only once the interest rate environment is negative. Consistently, a level surprise to the yield curve also only starts to impact a bank's return on assets once interest rates have turned negative. In times of negative interest rates, a parallel drop of 10 basis points in the yield curve reduces the deposit margin and return on assets by approximately 0.2 and 0.5 percentage points, respectively. Moreover, a flattening of the longer-end slope of the yield curve does not impact the deposit margin, and in fact increases a bank's return on assets when rates are negative. These results help to explain why bank stock prices start to underperform the broader market in a negative interest rate environment. However, an unanticipated change in the shorter-end slope of the yield curve induced by monetary policy is not found to significantly affect a bank's income through the deposit margin.

3.5. Other robustness checks

Several other robustness checks are performed (all available upon request). First, all models estimating the impact of monetary policy surprises on bank stock prices are augmented with the first lag of the dependent variable on the right-hand side of the equation to address potential concerns that the relationship is dynamic. The estimated coefficients of the lagged dependent variable are close to zero and the main results remain unaffected, both statistically and economically. This is in line with the view that stock prices are forward-looking, reflecting the market valuation of equity based on the expected future discounted cash flow at any point in time. Second, the size of the rolling estimation windows is changed using all rolling regression models. Increasing the number of observations yields similar results. Decreasing the number of observations also gives similar results, except that the fourth day after a surprise to the level of the yield curve, the effect on bank stock prices reverses. The fourth day after an unanticipated flattening of the shorter-end of the yield curve, bank stock prices remain significantly lower. Third, the forecast horizon is extended with several days in models (3), (4), (5) and (6). The persistence of the effects remains. Fourth, the (T)LTRO dummy is excluded from the right-hand side of all estimated models, so as to verify that its inclusion does not drive any of the results. While the estimated coefficients of the (T)LTRO dummy are statistically significant in the estimation windows covering most of the negative interest rate period, the results are similar when excluding this control variable.

Table 5
Effects of monetary policy on balance sheet and income statement items.

Regressors	Deposit margin			Return on assets		
	1 High rates	2 Low rates	3 Negative rates	4 High rates	5 Low rates	6 Negative rates
Level surprise	0.0896	0.0441	0.0192***	−0.5700	0.0598	0.0541*
	(0.3867)	(0.1152)	(0.0069)	(4.0881)	(0.5731)	(0.0309)
Shorter-end slope surprise	−0.1315	0.0096	−0.0008	−0.8881	0.0108	0.0038
	(0.5619)	(0.0224)	(0.0029)	(6.3671)	(0.1275)	(0.0107)
Longer-end slope surprise	0.2430	0.0748	0.0012	−1.6854	0.1108	−0.0160**
	(1.0815)	(0.2145)	(0.0018)	(11.9487)	(1.0392)	(0.0065)
N	91	325	326	91	321	326

Notes: This table shows fixed effects IV estimations for model (7), using the within-quarter average of the monetary policy surprises as external instruments for the quarterly changes in the different segments of the yield curve. The dependent variable measures a bank's deposit margin in columns 1, 2 and 3, and a bank's return on assets in columns 4, 5 and 6. The columns show the effects of monetary policy surprises to the level, shorter-end slope and longer-end slope of the yield curve in times of high, low and negative interest rates, respectively. In addition to the bank fixed effects, all columns include macroeconomic and bank control variables. Robust standard errors clustered across banks and time are included in parentheses. Significance levels: $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

4. Conclusion

A prolonged period of negative interest rates has implications for the performance of banks, as retail deposit rates are stuck at zero. Against this background, this paper investigates whether bank stock prices react differently to changes to the shorter- versus the longer-end of the yield curve in times of negative interest rates. Unanticipated interest rate changes are identified with high-frequency data around 269 ECB monetary policy announcements from January 1999 to January 2020.

The results indicate that negative interest rates matter for bank stock prices. Controlling for broad stock market movements, an unanticipated downward shift in the yield curve and a flattening of the shorter-end of the yield curve resulting from monetary policy announcements persistently reduce bank stock prices in a low and especially in a negative interest rate environment. Bank stocks thus face a disadvantage compared to the broad stock market when interest rates are negative. This is consistent with the deposits channel of monetary policy. Three sets of results reinforce this conclusion. First, once the interest rate environment turns negative, level and shorter-end slope surprises have a larger effect on stock prices of banks that are relatively dependent on deposit funding. In such an environment, deposit margins may turn negative as a result of sticky deposit rates, which has a stronger impact on the performance of deposit-dependent banks. Second, the days after the announcement, the effects are also more persistent for banks that are relatively dependent on deposit funding. Third, flattening the longer-end of the yield curve does not generate significant effects on bank stock prices in times of negative interest rates. Deposit margins may remain relatively unaffected when targeting only the longer-end slope of the yield curve due to the lower average duration of deposits. Indeed, accounting data indicate that a parallel drop in the yield curve has an adverse impact on bank performance through shrinking deposit margins when interest rates are negative.

Looking forward, a prolonged period of negative interest rates may be expected to hurt bank performance. This may reduce bank lending, hamper the transmission of monetary policy stimulus and increase financial stability risks. The design of monetary policy can take this into account. The findings suggest that distortions stemming from deposit rates bound at zero are lower when targeting the longer- rather than the shorter-end of the yield curve in a negative interest rate environment. From this perspective, quantitative easing and yield curve control deserve special consideration when interest rates are low and further monetary accommodation is called for.

CRediT authorship contribution statement

Joost V. Bats: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Massimo Giuliodori:** Conceptualization, Methodology, Verification, Resources, Writing – review & editing, Supervision. **Aerdt C.F.J. Houben:** Conceptualization, Methodology, Verification, Resources, Writing – review & editing, Supervision.

Data availability

Data will be made available on request.

Appendix

See Table A.1, Figs. A.1–A.3.

Table A.1
Effects of monetary policy on the broad market index.

Regressors	Broad market	Banks while controlling for market
Level surprise * high rate environment	−0.09	0.06
	(0.10)	(0.04)
Level surprise * low rate environment	0.30***	0.16**
	(0.11)	(0.07)
Level surprise * negative rate environment	−0.24***	0.11***
	(0.04)	(0.03)
Shorter-end slope surprise * high rate environment	−0.08	0.05
	(0.10)	(0.04)
Shorter-end slope surprise * low rate environment	0.20***	0.13**
	(0.07)	(0.05)
Shorter-end slope surprise * negative rate environment	−0.21***	0.13***
	(0.03)	(0.04)
Longer-end slope surprise * high rate environment	−0.18	0.17**
	(0.17)	(0.08)
Longer-end slope surprise * low rate environment	0.33*	0.24*
	(0.17)	(0.13)
Longer-end slope surprise * negative rate environment	−0.01	−0.03
	(0.05)	(0.10)
N	5,160	5,142

Notes: This table shows regressions of the daily broad market return, and the daily bank stock index return while controlling for the broader market, on the monetary policy surprises to the level of the yield curve, the difference between the 5-year and 1-month rate and the difference between the 10- and 5-year rate in times of high, low and negative interest rates, respectively (the surprises equal zero on the days of no monetary policy announcements). The parentheses include Newey and West standard errors. Constant not shown.

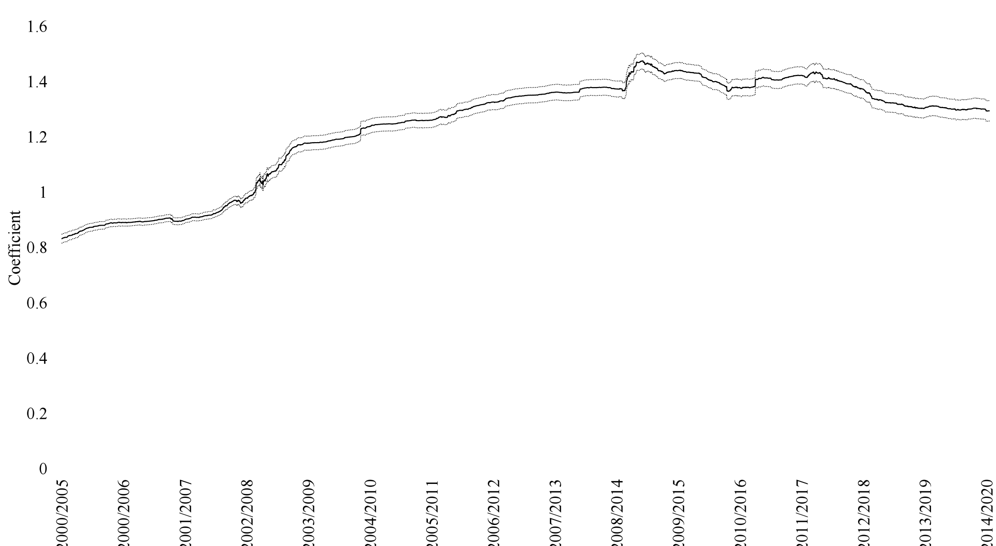

Fig. A.1. CAPM beta of the bank stock index.
Notes: This figure shows the CAPM beta of the SX7E, which is estimated using a rolling regression of daily log changes in the bank stock index on daily log changes in the broad stock market index. The dotted lines represent the 90% confidence interval.

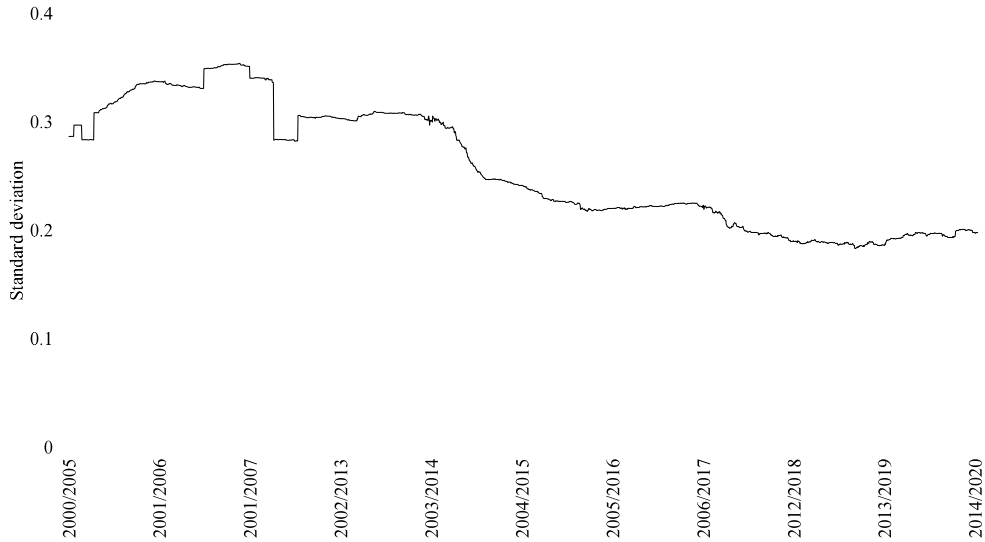

Fig. A.2. Dispersion in the CAPM betas of the individual bank stock prices.
Notes: This figure shows the standard deviation in the CAPM betas of the individual bank stock prices, which are estimated using a rolling panel regression of daily log changes in the individual stock prices on daily log changes in the broad stock market index.

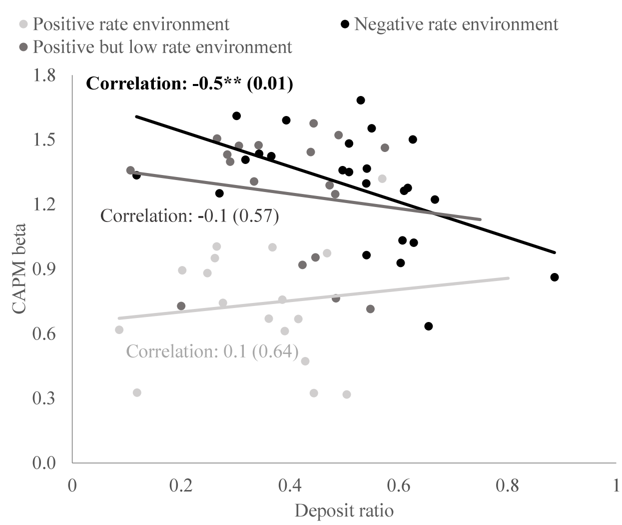

Fig. A.3. Correlations between the individual CAPM betas and deposit ratios.
Notes: This figure shows the correlations between the individual banks' average CAPM betas and deposit ratios in times of positive, positive but low and negative interest rates. P-values are included in parentheses.

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