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European bank margins at the zero lower bound

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ABSTRACT

Post-2014, the zero lower bound on household deposits has intensified the downward pressure of the ECB's accommodative monetary policy on banks' net interest margins. Using a shadow rate to capture the stance of (unconventional) monetary policy, we construct counterfactual deposit rates, representing the path that deposit rates in 10 euro area countries would have followed in absence of the zero lower bound. Based on this counterfactual, we investigate whether banks attempt to compensate foregone deposit margins by increasing their lending margins. Our results show a substantial degree of margin compensation (around 44%). Moreover, banks which are highly dependent on net interest income increase their lending margins more, while higher shares of fee and commission income soften the compensation effect. Our estimations reveal important heterogeneity across euro area countries, with the end-2019 impact on lending margins ranging from negligible to more than 100 bps. These findings have implications for bank profitability, but also for the transmission of monetary policy to bank lending.

1. Introduction

Traditionally, the core function of banking consists in financial intermediation between savers and borrowers (Diamond, 1984). From this intermediation activity, banks earn a net interest margin (NIM) which can be decomposed in three components: the yield spread (the difference between the risk-free long-term and short-term interest rate, when banks engage in maturity transformation), the lending margin (a bank grants loans to borrowers at an interest rate above the benchmark risk-free rate) and the deposit margin (a bank with access to deposits should be able to attract funding at a cost lower than the market rates). Today, this traditional intermediation function still forms the core of banking and hence the NIM remains the most important component of bank profitability (ECB, 2019).

In the post-GFC period, the ECB's accommodative monetary policy has put banks' NIM under substantial pressure. Lending rates have been pushed lower by (unconventional) monetary policy in order to stimulate lending and economic activity in the euro area. Moreover, the low-for-long interest rate environment has compressed the yield spread to historical lows. The impact of accommodative monetary policy hurts banks' NIM even more when the retail customer deposit rate starts hitting the zero lower bound (ZLB), since lower lending rates can then no longer be offset by lowering the rates offered on deposits, which causes the NIM to compress further. Given the importance of the NIM for bank profitability, banks have an incentive to offset the pressure on their intermediation margin. Using theoretical models, Eggertsson et al. (2019) and Ulate (2021), among others, have argued that this may cause contractionary (or less expansionary) effects on lending, with

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bank lending rates disconnecting from decreasing policy rates, i.e. banks increasing lending margins. We empirically test whether or not banks partially compensate the declining profitability contribution of the deposit margin, which has even become negative, by increasing their lending margin.

We investigate this hypothesis using household lending and deposit rates for 10 euro area countries over the period 2003–2019. Our main contribution is the construction of a counterfactual (shadow) deposit rate, i.e. the deposit rate banks would offer in the absence of a ZLB on household deposits. As a benchmark rate to predict the counterfactual deposit rate, we use the Wu and Xia (2017) shadow rate which is an extension and adaptation to the euro area of Wu and Xia (2016). The shadow rate is an indicator of the monetary policy stance based on the yield curve dynamics up to 10 years. Since various types of unconventional monetary policy have an impact on different parts of the yield curve, the shadow rate captures the full effect of unconventional measures. An attractive feature of the shadow rate is that it can go below zero as a reflection of the very accommodative monetary policies conducted by the ECB: the negative deposit facility rate (DFR), the consecutive asset purchase programs, (T) LTROs and forward guidance. The lower the shadow rate, the more monetary policy is perceived as accommodative by financial markets. In normal times, deposit rates track the evolution of the policy rate, but that relationship breaks down when banks are confronted with a ZLB on household deposits. Hence, the lower, i.e. the more negative, the shadow rate becomes, the more constrained banks are by the ZLB on retail deposits. Moreover, the more negative the shadow rate becomes, the longer it will take to get back above zero, hence the longer bank interest margins will remain compressed. We capture the pressure of the ZLB on retail deposits by the deposit rate gap, which is constructed by comparing the counterfactual deposit rate to the actual (realized) deposit rate. Our hypothesis is that banks will try to compensate part of this deposit rate gap by charging higher lending margins. An attractive feature of constructing this deposit rate gap is that it allows to quantify the absolute degree of margin compensation caused by the ZLB on retail deposits, whereas comparing treated and control banks (or countries) would only provide information on relative differences between these countries.

Our results indicate that the degree of margin compensation is substantial, in the order of magnitude of 44%. This finding has important implications for lending and the transmission of ECB monetary policy. If a change in monetary policy causes an increase in the deposit rate gap of 100 basis points (bps)[1], banks will increase their lending markup by around 44 bps, compared to a similar change in monetary policy in positive interest rate territory. This shows that accommodative monetary policy near the ZLB is less effective compared to a positive interest rate situation. We also find that the compensation effect is stronger for banks with higher shares of net interest income, while banks with more fee and commission income are less inclined to increase their lending margins. Moreover, we document important heterogeneity across euro area countries. At the end of 2019, the pressure of the ZLB on household deposits pushed Austrian banks' lending margins approximately 126 bps higher. Italian and Dutch banks are situated at the other end of the spectrum: their lending margins are only about 7 and 25 bps higher because of the compensation effect. For France, Portugal and Spain, the effect is between 40 and 50 bps. For Belgium, Germany, Ireland and Finland, the effect on the lending margin is approximately 80 to 100 bps. These results also yield implications for bank managers. Because the compensation effect is only partial, banks are unable to fully compensate the impact of the ZLB on their NIMs, which calls for increased focus on cost efficiency and functional (revenue) diversification.

The remainder of the paper is organized as follows. In Section 2, we elaborate on our contribution to the literature. In Section 3, we discuss our data and methodology, followed by the results in Section 4. We conclude in Section 5.

2. Literature overview

Our analysis is firmly situated in the literature examining the determinants of bank interest margins. In their seminal paper, Ho and Saunders (1981) modeled a bank as 'a dealer' of deposits and loans, setting an optimal mark-up or margin on top of money market rates. The drivers of bank margins and profits have been the object of interest in many papers since then (e.g. Claeys and Vander Vennet (2008), Albertazzi and Gambacorta (2009) and Alessandri and Nelson (2015)). While policy and market rates have always played a role in these studies, recent attention has shifted towards investigating the impact of lower (or negative) policy rates and a flattening yield curve on banks' net interest margin and overall profitability. Borio et al. (2017), Claessens et al. (2018) and Molyneux et al. (2019) find for broad samples of banks in cross-country panels that low interest rates are associated with lower bank NIMs and return on assets. Altavilla et al. (2018), however, argue that accommodative monetary policy does not lead to lower bank profitability, once controlled for the effect on the expected macroeconomic environment. They document a negative impact on the NIM which is compensated by a positive effect on loan loss provisions and non-interest income. To check the relevance of our dataset, we confirm the positive relationship between the NIM on the one hand, and the level of policy rates and the slope of the yield curve on the other hand, using monthly bank interest rate data on new business, aggregated at the country level, rather than lower-frequency bank-level accounting data. Instead of investigating the full NIM, some papers focus on the lending margin, defined as the difference between the lending rate and the maturity-matched market rate (Wang, 2020). We follow this approach in our analysis and examine whether or not banks attempt to compensate part of the deposit rate gap, caused by the ZLB on household deposits, by increasing their lending margins.

Another strand of the literature analyzes the pass-through of monetary policy rates to bank interest rates. Hofmann and Mizen (2004) provide a theoretical and econometric framework to assess this pass-through. Typically, a cointegrating rela-

[1] E.g. following a change in monetary policy, banks would ideally want to reduce their deposit rates by 100 bps, but they are constrained by the ZLB.

tionship between money market and bank interest rates is estimated from which the speed and magnitude of the pass-through can be derived. Sander and Kleimeier (2004) propose a unifying approach for the empirical literature on interest rate pass-through. de Bondt (2005) finds that the long-run pass-through for most categories of loans and deposits is almost complete, except for short-term deposits. By applying a non-linear analysis, De Graeve et al. (2007) show that there is some asymmetry in upward and downward deposit rate adjustments in Belgium and that larger deviations from equilibrium mark-ups lead to faster adjustments for lending and deposit rates. Belke et al. (2013) document non-linearities in the pass-through of money market rates to euro area lending rates. An overview of the pass-through literature for the euro area up to 2015 is available in Andries and Billon (2016). More recently, Illes et al. (2019) argue that lending rates have diverged from policy rates after the financial crisis, but not from funding costs, while Altavilla et al. (2020) investigate heterogeneity in the pass-through of euro area monetary policy to bank lending rates. With bank deposit rates close to the ZLB, different papers show a weakening of the pass-through to deposit rates (Eggertsson et al., 2019; Heider et al., 2019; Wang, 2020). Altavilla et al. (2022) focus on euro area corporate deposits and find evidence of reduced pass-through after the ECB lowered the DFR below zero, albeit with large cross-sectional differences across banks. We contribute to this literature by analyzing the pass-through of (unconventional) monetary policy, measured by the shadow rate, to banks' deposit pricing. Following the approach of Hoffmann et al. (2019) and Drechsler et al. (2021), we estimate a deposit beta and we use this beta to construct out-of-sample forecasts of a counterfactual (shadow) deposit rate which represents the path of the deposit rate that would have prevailed in absence of the ZLB. The gap between the realized and counterfactual deposit rate can be used to measure the impact of the ZLB on household deposits.

Recently, there has been increased attention in the literature to investigate whether negative interest rates have impaired the transmission of monetary policy to bank lending. Empirical work by Borio and Gambacorta (2017) shows, for a sample of international banks, that monetary policy is less effective in stimulating lending growth when interest rates are low, because of the impact of low rates on bank profitability. For the euro area, Heider et al. (2019) find that high-deposit banks, which are hit more by the ZLB on deposits, reduce their supply in the syndicated loan market when interest rates move into negative territory, because of the adverse effect on these banks' net worth. Demiralp et al. (2021), however, argue that negative interest rates have a positive impact on the supply of loans for banks with a combination of high deposits and excess liquidity. Similarly, Horvath et al. (2018) argue, using euro area data up to 2016, that negative interest rates do not reduce bank interest rates' responsiveness. Wang (2020), on the other hand, finds that low interest rates contract the long-run supply of bank credit in the US, by increasing the spread on loans. Eggertsson et al. (2019) show an increase in lending rates and a decrease in lending volumes in response to policy rates going negative in Sweden. Additionally, they build a model in which the decrease in credit supply is explained by the collapse of the bank lending channel, driven by the ZLB on deposits. Focusing on Switzerland, Basten and Mariathasan (2020) document that banks' ability to offset the impact of negative policy rates by increasing mortgage margins depends on their market power. In a theoretical model, Brunnermeier and Koby (2018) show that there is a reversal rate, i.e. a (negative) policy rate at which monetary policy intended to be accommodative in fact becomes restrictive. A key difference w.r.t. most empirical papers, is that the reversal rate in Brunnermeier and Koby (2018) occurs because of a reduction in bank value combined with binding capital constraints. Additionally, Ulate (2021) and Onofri et al. (2021) show that monetary policy transmission in negative territory can still be expansionary, but is less effective compared to positive territory. In the model of Wang et al. (2022), the interaction of market power and bank capital regulation is key for the existence of a reversal rate. We contribute to this literature by empirically investigating whether ultra-loose accommodative monetary policy[2], which causes retail deposit rates to become constrained by the ZLB, pushes euro area banks to increase their lending margins. We argue that when retail deposit rates reach their ZLB, the deposit margin becomes negative: money market rates fall below zero, while the retail deposit rate remains bounded at zero percent. As a result, the total NIM of a bank is under pressure and since this constitutes the largest component of bank profitability, banks have the incentive to increase the only margin under their control, the lending margin.

Hence, our main hypothesis is that banks, under pressure by the low-for-long interest rate environment, will (partially) compensate for the higher cost of retail deposit funding by increasing the margin charged on household loans in order to protect their profitability.[3] Our focus is on loans for house purchases (mortgages), because they represent a very important and increasing share of banks' total lending portfolio (Jordà et al., 2016; Hoffmann et al., 2019).[4]

3. Data and methodology

3.1. Data

We use monthly data for a sample of 10 euro area countries[5] from January 2003 to December 2019. Data on bank interest rates are retrieved from the Monetary Financial Institutions (MFI) statistics in the ECB Statistical Data Warehouse (SDW).[6] This

[2] Which includes, but is not limited to, negative interest rate policy.

[3] While the impact of the ZLB on euro area lending volumes has been discussed in existing literature (Heider et al., 2019; Demiralp et al., 2021), the evidence on the impact on lending margins is scarce.

[4] Mortgages account for around 30% of total loans for the 10 euro area countries in our sample at the end of 2019.

[5] The countries included in the sample are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain.

[6] Other papers using similar data from the MFI statistics database are for example, Belke et al. (2013) and Illes et al. (2019).

approach allows to obtain a harmonised dataset over different countries, with the longest possible time span. Since our main interest is in the core intermediation function of retail banking, we focus on household loans and deposits. For the lending side, we use the category *lending for house purchase excluding revolving loans and overdrafts, convenience and extended credit card debt*, which is calculated in SDW by weighting the volumes with a moving average. We use the rate on newly issued loans to capture changes in bank lending conditions immediately. For the deposit side, we calculate a volume-weighted average rate of 3 categories with a maturity up to 2 years.[7]

By using country-level SDW data on loans and deposits, we deviate from many papers investigating the impact of monetary policy on interest rates and margins, which use bank-level data (Borio et al., 2017; Claessens et al., 2018). Except if proprietary datasets are used (e.g. Altavilla et al. (2018)), a shortcoming of bank-level data is that these are typically only available at yearly (or at best quarterly) frequency. Moreover, given that they consist of balance sheet or income statement data, these variables tend to react slowly to changes in monetary policy (Agapova and McNulty, 2016). As an example, a bank's NIM in a certain year is heavily influenced by the interest rate agreed on (fixed rate) loans in earlier years, which is not influenced by changes in e.g. monetary policy in that specific year. Third, bank-level data require the authors to make decisions on which banks to include in the dataset, which could lead to selection biases. Using SDW data enables us to overcome these issues. First, the interest rates in the SDW are available at monthly frequency since the start of the database in 2003. Second, these data allow to define an ex-ante (forward-looking) NIM as the difference between the lending rate on new loans and the deposit rate on new deposits. This measure is an indication of the most recently updated intermediation margin that a bank can receive and it is therefore the appropriate variable to assess the impact of changes in monetary policy on bank behaviour.[8] Following a similar reasoning, we define an ex-ante lending margin as the difference between the lending rate on new loans and the 5-year OIS rate. Third, the SDW dataset ensures that every country's entire banking sector is adequately represented in the sample, or at least that the choice to include or exclude banks is made in a harmonised manner for all countries.

Even though the monthly SDW data on new loans and deposits offer several benefits, a trade-off of country-level data (compared to bank-level data) is that they are, by definition, aggregated. Therefore, we first show that our country-level data adequately capture interest rate dynamics, by confirming earlier results in this research area which are based on bank-level data. We follow Claessens et al. (2018) and investigate the impact of the short-term interbank rate and yield spread on banks' NIM. Completely in line with the existing literature, we find that the low-for-long interest rate environment, which puts downward pressure on the short-term rate and flattens the yield curve, hurts net interest margins (Borio et al., 2017; Claessens et al., 2018; Molyneux et al., 2019). The methodology and detailed results are discussed in Appendix A.

Summary statistics for the bank interest rates are shown in Panel A of Table 1. The average lending rate over the period is 3.27%, with a maximum of 6.07% for Spain in October 2008 and a minimum of 0.75% for Finland in September 2019. The average deposit rate over the period is 1.09%, with a maximum of 3.96% for Austria in October 2008 and a minimum of 0.03% for Spain in September 2019. These statistics are an indication of the decreasing trend in bank interest rates over the past decade. To give further insight in the evolution of euro area bank interest rates over the period, we plot the average (over the 10 countries) of both rates in Fig. 1.

To capture the interest rate environment, we use a number of different benchmarks. For the short and long end of the yield curve we use the EONIA and the 5-year OIS rate, respectively. As a measure of the (unconventional) monetary policy stance, we use the euro area shadow rate proposed by Wu and Xia (2016) and Wu and Xia (2017), which is retrieved from the authors' website. Given the focus of our paper on deposit rates, the shadow rate has a clear advantage over other monetary policy variables, as will be explained in more detail below (cf. Section 3.2). Note that the Wu and Xia (2017) shadow rate is only available from September 2004 onwards. However, before the GFC, the shadow rate almost perfectly tracked the EONIA rate. Therefore, we replace the shadow rate by the EONIA rate for the January 2003 to August 2004 period.[9] These rates are retrieved from Refinitiv and plotted in Fig. 1. The summary stats are shown in Panel B of Table 1.

Since our dataset comprises different countries in the euro area, we have to take into account their economic and structural characteristics, using appropriate control variables. We use the share of household deposits to proxy for the retail orientation of the banking sector and the unweighted capital ratio to capture bank resilience. The shares of securities[10] and cash[11] as percentage of total assets are included to control for asset allocation decisions. In a robustness check, we also take into account changes in mortgage maturities. Differences in countries' economic conditions are captured by (expected) GDP growth, (expected) inflation, expected unemployment, the consumer confidence index (CCI) and the house price index (HPI) as measures for demand and supply effects and nominal contracting (Claeys and Vander Vennet, 2008; Albertazzi and Gambacorta, 2009). As a measure for sovereign risk, we use the 5-year CDS spread on government bonds. Except for the share of cash (quarterly), all bank sector control variables are of monthly frequency. For the macroeconomic variables, we have a combination of monthly (inflation, sovereign CDS spread, CCI), quarterly (GDP growth, HPI), semi-annual (expected GDP growth,

[7] The selected categories are *overnight deposits*, *deposits with agreed maturity up to 2 years* and *deposits redeemable at notice up to 3 months*. Gaps in the data series are filled with the corresponding data obtained from the respective national central bank websites.

[8] Therefore, Agapova and McNulty (2016) advocate the use of this variable, which they call 'interest rate spread', over the use of the traditional ex-post NIM. To facilitate comparison with other studies, we nevertheless call our 'interest rate spread' variable 'NIM' in the remainder of this analysis.

[9] If we omit January 2003 to August 2004 instead, the results are completely equivalent. Results available upon request.

[10] Consisting of holdings of debt securities, MMF shares/units and equity and non-MMF investment fund shares/units.

[11] Cash, cash balances at central banks and other demand deposits.

Table 1
Descriptive statistics.

Variable	Explanation	Source	Obs.	Mean	SD	Min	Max
Panel A: Bank interest rates							
LendingRate	Lending rate (%)	SDW	2040	3.27	1.15	0.75	6.07
DepositRate	Deposit rate (%)	SDW	2040	1.09	0.81	0.03	3.96
NIM	LendingRate – DepositRate (%)	SDW	2040	2.17	0.62	0.67	4.18
LendingMargin	LendingRate – OIS^{5Y} (%)	SDW	2040	1.55	0.93	−0.47	3.67
Panel B: Interest rate environment							
EONIA	EONIA rate (%)	REF	2040	1.06	1.45	−0.46	4.30
OIS^{5Y}	5-year OIS rate (%)	REF	2040	1.72	1.59	−0.64	4.65
ShadowRate	Shadow rate (%)	WU	1840	−0.81	3.34	−7.82	4.28
Panel C: Bank and mortgage characteristics							
$Deposits^{HH}$	Household deposits (% of assets)	SDW	2040	20.41	6.87	4.68	39.56
Capital	Capital and reserves (% of assets)	SDW	2040	7.23	2.50	3.37	15.34
Securities	Securities (% of assets)	SDW	2040	21.92	8.25	8.86	49.03
Cash	Cash (% of assets)	SDW	1455	4.87	4.15	0.40	26.30
Maturity	Average mortgage maturity (years)	EMF HS	756	23.93	5.45	7.00	33.40
Panel D: Macroeconomic characteristics							
GDPGrowth	GDP growth (%)	SDW	2040	1.56	3.19	−9.70	29.40
Inflation	Inflation (%)	REF	2040	1.62	1.22	−2.90	5.90
ExpGDPGrowth	Expected GDP growth (%)	IMF	2040	1.64	1.09	−3.00	5.60
ExpInflation	Expected inflation (%)	IMF	2040	1.57	0.62	−2.60	3.40
ExpUnempl	Expected Unemployment (%)	IMF	1960	8.67	4.12	2.90	26.66
$SovCDS^{5Y}$	5-year sovereign CDS spread (%)	IHS	2001	0.66	1.27	0.01	15.54
CCI	Consumer confidence index (–)	EC	2040	−10.34	9.59	−46.30	11.40
HPI	House price index (2015=100)	REF	1611	104.69	17.92	56.48	163.29

This table shows the number of observations, mean, standard deviation, minimum and maximum for the different bank interest rates (Panel A), interest rate environment variables (Panel B), bank and mortgage characteristics (Panel C) and macroeconomic variables (Panel D) used in our analysis. The data is obtained from the Statistical Data Warehouse (SDW), Refinitiv (REF), Wu and Xia (2017) (WU), EMF Hypostat reports (EMF HS), the IMF World Economic Outlook (IMF), IHS Markit (IHS) and the European Commission (EC) as displayed in the third column.

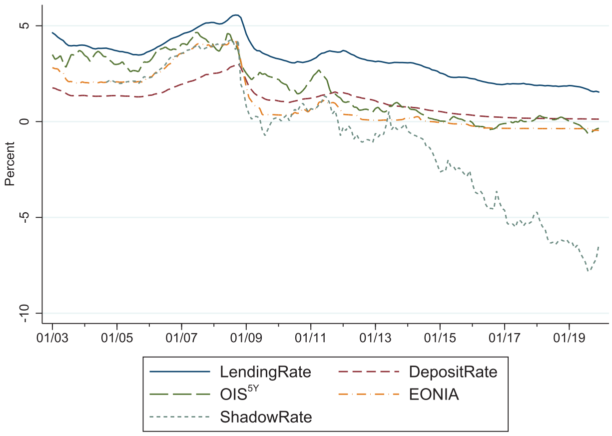

Fig. 1. Key euro area interest rates (unweighted average of 10 countries).

expected inflation, expected unemployment) and annual (mortgage maturity) data. For variables with a quarterly or (semi-) annual frequency, we repeat observations over the reported period to obtain a balanced monthly panel. To calculate lags or differences of these variables, we use information on the previous quarter or (half) year, respectively. The bank, mortgage and macroeconomic variables are summarized in Panel C and Panel D of Table 1. Note that the share of cash is only available from 2007 or 2008 onwards, depending on the country. However, since we use this variable in the second step of the analysis (starting in 2014), this is not a concern. The same applies to the HPI, which is available for all countries from 2010 onwards, and for mortgage maturities, which are collected from 2013 onwards but are only available for all countries after 2014.

3.2. Methodology

Our main contribution is that we examine whether banks try to compensate decreasing margins on deposits by increasing lending margins, following a two-step approach. In the first step, we construct country-specific counterfactual deposit rates, which represent the path that deposit rates would have followed in absence of the ZLB. The second step consists of investigating whether banks active in countries which are hit by the ZLB on household deposits increase their lending margins. Deposit rates typically track the evolution of the policy rate during normal times. However, if deposit rates approach zero, they become constrained by the ZLB on retail deposits: according to the evolution of the policy rate, banks would like to decrease their deposit rates further, but they are unable to do so, which harms their deposit margins and ultimately their profitability. Our hypothesis is that in these circumstances banks will compensate some of the foregone deposit margin by increasing lending margins.

To construct counterfactual deposit rates, we split the data in two periods: an estimation and a prediction period. As baseline estimation period, we use January 2003 (start of the sample) to December 2013. The latter date is chosen to ensure that all GFC-related policy rate changes are priced into banks' deposit rates before the end of the estimation period.[12] In this period, we establish a link between deposit rates and the policy rate during 'normal' times, i.e. with deposit rates not hitting the ZLB yet. This is used to predict counterfactual deposit rates (assuming no ZLB) in the subsequent prediction period. An important innovation is that we construct the counterfactual deposit rates based on the Wu and Xia (2017) euro area shadow rate as a measure of the monetary policy stance. By using yield curve dynamics up to 10 year, the shadow rate captures the full effect of unconventional measures. This cannot be captured by e.g. the DFR or the EONIA (which is bounded by the DFR). As a result, the shadow rate allows to identify when and how much banks are constrained by the ZLB. Moreover, banks commonly use replicating portfolio models, typically with maturities up to 10 years, to estimate the duration of their non-maturing deposits and to hedge their interest rate sensitivity accordingly (Kalkbrener and Willing, 2004). Hence, using shadow rates which capture yield curve dynamics up to 10 year to forecast counterfactual deposit rates can serve as a reasonable approximation of these models. We prefer the shadow rate developed in Wu and Xia (2017), because it is calibrated on the time-varying DFR in the euro area, it allows agents to be forward-looking in terms of the lower bound and it incorporates the non-constant spread between policy rates and government bond yields.

We start the first step by estimating, for every country separately, the sensitivity of the deposit rate to policy rate changes. To do so, we follow Hoffmann et al. (2019) and Drechsler et al. (2021), and run the following time series regression for each country during the estimation period:[13]

$$\Delta DepositRate_t = \alpha_0 + \sum_{j=0}^{J} \beta_j \Delta ShadowRate_{t-j} + \epsilon_t \quad (1)$$

Based on the β_j coefficients estimated in Eq. 1, we predict the country-specific deposit rates in the subsequent prediction period ($DepositRate^*_{c,t}$), i.e. from January 2014 to December 2019. To do so, we impute realized values of the shadow rate and its lags during the prediction period. These predictions can be considered as counterfactual deposit rates which would have materialized in absence of the ZLB. With this out-of-sample prediction, we assume that the pass-through of monetary policy to deposit rates did not change between the estimation and prediction period, except for the effect of the ZLB. More specifically, it implies that the level of the policy rate only impacts the pass-through of monetary policy to deposit rates through the effect of the ZLB on deposits. The assumption that the pass-through remains stable over time is in line with the approach of Wang (2020). Moreover, we also test this assumption by splitting the estimation period (i.e. the non-ZLB period) in two subperiods, estimating the β_j coefficients based on the first subperiod and calculating out-of-sample changes in the deposit rate in the second subperiod. Based on the normalized root mean square error (NRMSE), we show that the model performs well in forecasting changes in the deposit rate out-of-sample. This robustness check is explained in more detail in Section 4.1. A second concern might be that deposit rates react asymmetrically to accommodative versus restrictive monetary policy. As Drechsler et al. (2017) show, the extent to which banks pass through changes in policy rates to deposit rates is a good measure for banks' market power in the deposit market.[14] Hence, β_j might be different depending on whether policy rates move up or down. Banks with market power will try to keep deposit rates as low as possible if policy rates increase (i.e. low β_j), whereas they will try to reduce deposit rates as much as possible if policy rates decrease (i.e. high β_j). Therefore, in a robustness check, we allow for heterogeneity in the β_j coefficients depending on whether monetary policy is accommodative or restrictive.In the second step, we investigate whether banks try to compensate the ZLB on deposits on the lending side. This analysis is implemented for the prediction period. Based on the counterfactual deposit rate, we construct a variable to measure the degree to which the ZLB hurts banks in different countries. A straightforward option would be to use the positive difference between the realized deposit rate and the counterfactual deposit rate in absence of the ZLB.[15]A disadvantage, however, is that this measure uses realized (contemporaneous) data on deposit rates. As a result, trying to link the lending margin of banks to this variable might suffer from reverse causality. To mitigate this issue, we use the $GAP^{ZLB}_{c,t}$ as main variable of interest in this analysis.

[12] For robustness checks on this cut-off date, cf. Sections 4.1 and 4.2.

[13] The number of lags (J) is based on the Akaike Information Criterion.

[14] Note that Drechsler et al. (2017) estimate deposit spread betas, while we estimate deposit (rate) betas. However, in their footnote 17, Drechsler et al. (2017) explain that deposit (rate) betas are by construction 1 minus deposit spread betas.

[15] Formally, we can define this variable as follows:

$$GAP_{c,t} = DepositRate_{c,t} - DepositRate^*_{c,t} \text{ if } DepositRate^*_{c,t} < DepositRate_{c,t}; \quad 0 \text{ otherwise}.$$

$$GAP^{ZLB}_{c,t} = |DepositRate^{*}_{c,t}| \text{ if } DepositRate^{*}_{c,t} < 0; \quad 0 \text{ otherwise.}$$

The intuition behind this variable is that the realized deposit rate should follow the counterfactual deposit rate relatively well (no deposit rate gap) until the ZLB is reached. From that point onwards, the realized deposit rate should remain rather constant, while the counterfactual is not impacted by the ZLB and can continue its downward movement. Hence the deposit rate gap will widen, which is captured by the $GAP^{ZLB}_{c,t}$. The advantage is that this variable does not use contemporaneous data[16], making reverse causality less likely.

To investigate potential compensation effects, we assume that banks price loans as a spread above the prevailing market rate (e.g. 5-year OIS rate), in line with Clark and Li (2022).[17] This lending margin, the difference between the lending rate and the long-term market rate, reflects, among other things, the riskiness of the loan, but banks might also use it to compensate for falling deposit margins. In a panel covering the prediction period, we estimate Eq. 2 to test this compensation hypothesis. As the deposit rate gap is non-stationary, we define the model in first differences to avoid spurious regression problems.[18]

$$\Delta LendingMargin_{c,t} = \alpha_c + \eta_t + \beta_0 \Delta GAP^{ZLB}_{c,t} + \sum_{j=1}^{J} \gamma_j CV^{j}_{c,t} + \epsilon_{c,t} \tag{2}$$

In this regression, the β_0 coefficient provides an estimate of the size of the compensation effect. A 1 percentage point (100 bps) increase in the deposit rate gap will cause an increase in the lending margin of β_0 percentage points. Besides a potential compensation effect, changes in lending margins might also be driven by (other) changes in supply, changes in demand or changes in the riskiness of the loans. To control for other supply-side factors, we include the lagged change in cash, cash balances at central banks and other demand deposits (as percentage of total assets) and the lagged change in household deposits (as percentage of total liabilities) in the regression. To capture demand effects, we add the lagged change in the country's consumer confidence index, as well as the change in expected GDP growth as additional control variables. Since we consider loans to households in our analysis, we also include the change in expected unemployment and the lagged change in house prices to control for changes in aggregate risk. In a robustness check, we also include the change in the average mortgage maturity as an additional control variable, because changes in the lending margin might also be driven by a change in maturity (and hence a change in the exposure to interest rate risk).[19] In the baseline regression specification, country fixed effects (α_c) and year fixed effects (η_t) are included to account for unobserved heterogeneity in the cross-sectional and time dimension. Standard errors are clustered at the country level.

Additionally, banks' ability or necessity to compensate the pressure of the ZLB might depend on various bank characteristics. First, theoretical papers argue that interest rate cuts in negative territory might work contractionary, because of a combination of an erosion of bank profitability and restrictive capital constraints (Ulate, 2021; Brunnermeier and Koby, 2018; Eggertsson et al., 2019). Therefore, we add interactions between the change in the deposit rate gap on the one hand and the share of net interest income in total income (*NII*), the share of fee and commission income in total income (*Fee*), return on assets (*ROA*), the share of household deposits in total liabilities ($Deposits^{HH}$) or the unweighted capital ratio (*Capital*)[20] on the other hand. We hypothesize that banks which are more dependent on net interest income are more incentivized to compensate the pressure of the ZLB, while this is potentially less the case for banks with more fee and commission income or higher profitability. Following Heider et al. (2019), banks funding themselves with more (household) deposits might also feel the pressure of the ZLB more. If the main channel works via binding capital constraints, banks with lower capital ratios are expected to show more aggressive compensation behaviour. However, structural factors might constrain banks in their ability to compensate the pressure of the ZLB on household deposits. This could be the case for banks with low market power or a high share of loans issued with floating (variable) rates. In order to test these hypotheses, we add interactions of the change in the deposit rate gap and banks' market power (*MarketPower*)[21] or share of floating-rate loans in total loans (*FloatLoans*). Formally, we estimate Eq. 3. For all interaction variables, we use pre-prediction period (i.e. end-2013) levels, as shown in Table B.1 in Appendix B. We demean these variables to facilitate the interpretation of the β_0 coefficient. This coefficient captures the size of the compensation effect for a bank with average value for the variable used in the interaction effect. Finally, we check whether there are differential effects between GIIPS and non-GIIPS countries, by adding an interaction with a dummy (D^{GIIPS}_c).[22]

[16] Except for the contemporaneous shadow rate, but this variable is constructed at the level of the euro area, not the individual country level. Moreover, using monthly data makes it unlikely that policy rates will react to retail rates contemporaneously.

[17] Ample robustness tests show that our results do not depend on the choice of market rate.

[18] The Im et al. (2003) test, a panel version of the Augmented Dickey Fuller test, does not reject the null hypothesis that the deposit rate gap is non-stationary for all countries (p-value of 0.9672). Note that the test does reject the non-stationarity hypothesis for the lending margin (p-value of 0.0002), implying that a cointegration relationship between both variables is impossible.

[19] We do not include this variable in the baseline specification, because the variable is not available for all countries in the first year (2014).

[20] Using the CET1 ratio instead yields similar results.

[21] Obtained from Coccorese et al. (2021), who use a structural model framework to calculate an index measuring the competitiveness of oligopoly conduct per country. This approach has the advantage of not having to use proxies such as concentration or market share.

[22] D^{GIIPS}_c is 1 for Italy, Ireland, Portugal and Spain, 0 otherwise. We exclude Greece from our analysis, because Greek banks defaulted and were rescued by a combination of Emergency Liquidity Assistance measures and capital injections by the Hellenic Financial Stability Fund. Moreover, the Greek banking system faced capital controls and deposit withdrawal caps, rendering the analysis of Greek bank margins uninformative.

$$\Delta LendingMargin_{c,t} = \alpha_c + \eta_t + \beta_0 \Delta GAP^{ZLB}_{c,t} + \beta_1 \left(\Delta GAP^{ZLB}_{c,t} \times IntVar_c \right) + \sum_{j=1}^{J} \gamma_j CV^j_{c,t} + \epsilon_{c,t}$$

$$\begin{aligned} \text{with } IntVar_c \quad &= NII_c - \overline{NII}, \\ &= Fee_c - \overline{Fee}, \\ &= ROA_c - \overline{ROA}, \\ &= Deposits^{HH}_c - \overline{Deposits^{HH}}, \\ &= Capital_c - \overline{Capital}, \\ &= MarketPower_c - \overline{MarketPower}, \\ &= FloatLoans_c - \overline{FloatLoans}, \text{ or} \\ &= D^{GIIPS}_c \end{aligned} \quad (3)$$

Furthermore, we investigate whether the compensation effect varies over time by including interactions between the change in the deposit rate gap and year dummies (cf. Eq. 4). Because the change in the deposit rate gap is interacted with every year dummy and because year fixed effects are used, the change in the deposit rate gap and the year dummies are not included separately.

$$\begin{aligned} \Delta LendingMargin_{c,t} = \alpha_c + \eta_t &+ \beta_0 \left(\Delta GAP^{ZLB}_{c,t} \times D^{2014}_t \right) + \beta_1 \left(\Delta GAP^{ZLB}_{c,t} \times D^{2015}_t \right) + \beta_2 \left(\Delta GAP^{ZLB}_{c,t} \times D^{2016}_t \right) \\ &+ \beta_3 \left(\Delta GAP^{ZLB}_{c,t} \times D^{2017}_t \right) + \beta_4 \left(\Delta GAP^{ZLB}_{c,t} \times D^{2018}_t \right) + \beta_5 \left(\Delta GAP^{ZLB}_{c,t} \times D^{2019}_t \right) + \sum_{j=1}^{J} \gamma_j CV^j_{c,t} + \epsilon_{c,t} \end{aligned} \quad (4)$$

4. Results

In this section, we analyze whether euro area banks have compensated the pressure of the ZLB on household deposits by increasing lending margins over the 2014–2019 period. First, we construct a country-specific deposit rate gap, which indicates how hard banks in every country have been hit by the ZLB. Second, we investigate the impact of changes in the deposit rate gap on the lending margin. The evidence is consistent with the existence of a compensation effect. Third, we estimate the economic magnitude of this effect in every country.

4.1. Quantifying the deposit rate gap at the ZLB

In the first step, we construct counterfactual deposit rates per country, which depict the path that deposit rates would have followed in absence of the ZLB. We estimate, for every country separately, Eq. 1 in the estimation period. The coefficients from these regressions are subsequently used to predict (out-of-sample) counterfactual deposit rates in the prediction period, i.e. from January 2014 onwards. Fig. 2 shows the resulting counterfactual (DepositRate*) per country and how it deviates from the actual (realized) deposit rate. In a first group of countries (e.g. Austria), deposit rates were very low at the start of the prediction period (the vertical black line). Hence, the counterfactual deposit rate starts deviating almost immediately and a deposit rate gap occurs. At the other end of the spectrum, in the Netherlands, deposit rates were still rather high at the start of the prediction period. Indeed, we observe that the realized deposit rate in the Netherlands almost perfectly follows our counterfactual, until the end of the sample period, when the counterfactual goes below zero. In countries in between these two extremes (e.g. Spain), deposit rates still had some room to follow the counterfactual path, which is indeed what happens during the first part of the prediction period. However, as soon as the ZLB starts affecting the realized deposit rates, the deposit rate gap also appears in these countries. We use this deposit rate gap ($GAP^{ZLB}_{c,t}$) as a measure of the impact of the ZLB. An important advantage is that the approach allows the timing of the compensation effect to be different per country, depending on how quickly the ZLB starts hurting banks, as argued by Arce et al. (2020) and Bittner et al. (2022).[23] Table 2 shows summary statistics for the deposit rate gap.

Given the importance of this variable for the remainder of the analysis, we perform ample robustness checks to ensure that the deposit rate gap does not depend on the definition of the estimation period or choices in the specification of Eq. 1. First, Table 3 gives an overview of the country-specific deposit betas, calculated as the sum of the β_j coefficients in Eq. 1, in line with Drechsler et al. (2021). Column (1) shows deposit betas for the baseline estimation period (January 2003 until December 2013), whereas columns (2) to (6) show the results for alternative choices of the estimation period. Changing the estimation period does not cause the deposit betas to change meaningfully.

[23] In contrast to imposing a single date (e.g. negative DFR in June 2014) for all countries.

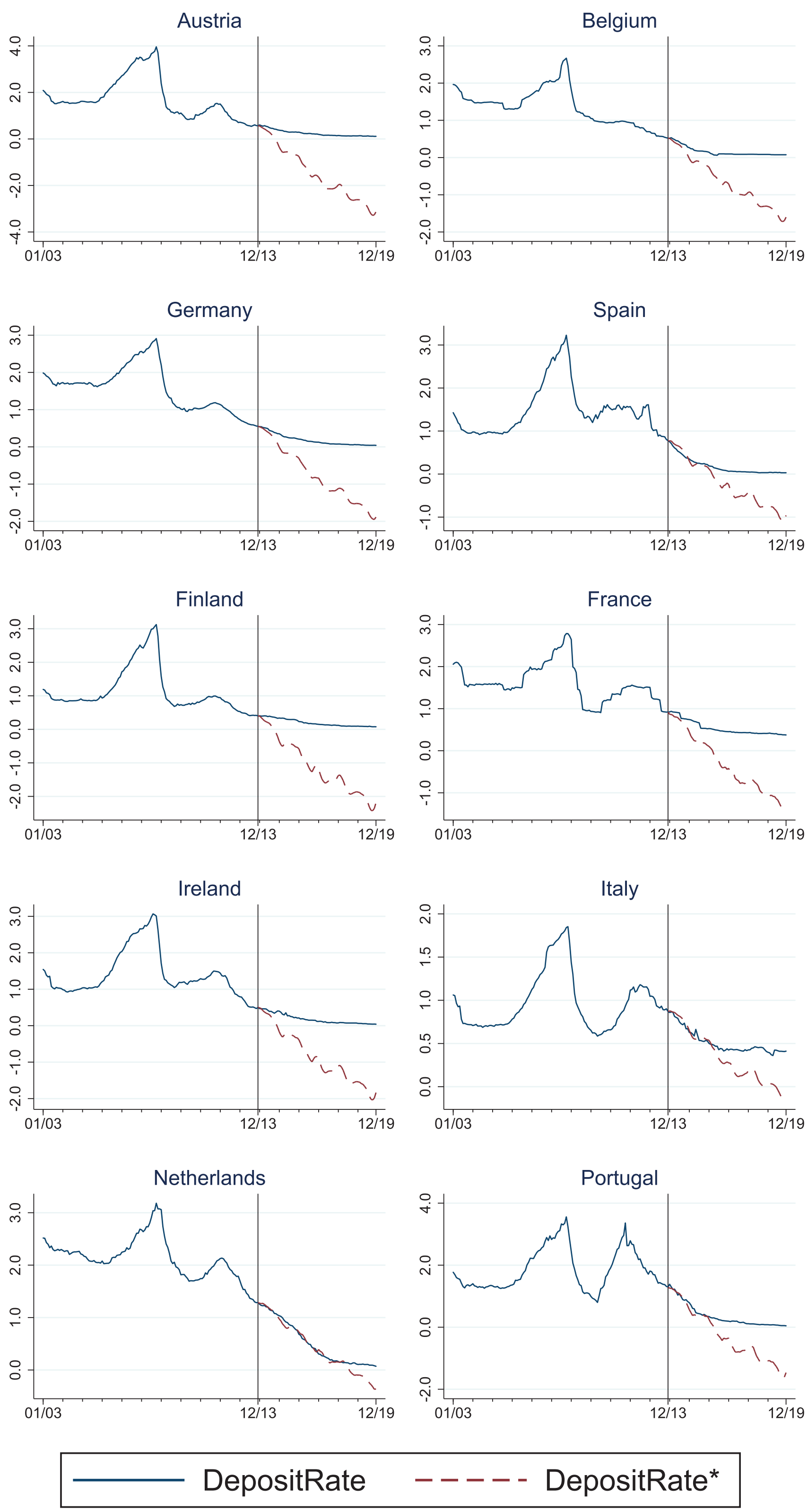

Fig. 2. Estimation of the counterfactual deposit rate.

Table 2
Descriptive statistics of the deposit rate gap.

Variable **Statistic**	GAP^{ZLB} **Mean**	GAP^{ZLB} **SD**	GAP^{ZLB} **Max**	GAP^{ZLB} **Months**	ΔGAP^{ZLB} **Mean**	ΔGAP^{ZLB} **SD**	ΔGAP_0^{ZLB} **Mean**	ΔGAP_0^{ZLB} **SD**
Austria	1.532	1.037	3.288	62	0.044	0.066	0.050	0.068
Belgium	0.719	0.560	1.721	60	0.023	0.039	0.027	0.041
Germany	0.829	0.637	1.950	60	0.027	0.035	0.031	0.036
Spain	0.357	0.350	1.098	46	0.014	0.039	0.021	0.048
Finland	1.135	0.749	2.424	63	0.031	0.066	0.035	0.069
France	0.488	0.470	1.424	45	0.020	0.037	0.031	0.042
Ireland	0.896	0.643	2.037	61	0.026	0.056	0.030	0.060
Italy	0.009	0.033	0.153	7	0.002	0.009	0.019	0.023
Netherlands	0.040	0.089	0.368	17	0.005	0.013	0.021	0.019
Portugal	0.519	0.519	1.605	44	0.021	0.055	0.033	0.066

The first 4 columns of this table show the mean, standard deviation and maximum for the estimated deposit rate gap (GAP^{ZLB}) variable in every country, as well as the number of months that the deposit rate gap is different from zero. Note that the minimum value for the deposit rate gap is zero in all countries by construction. The last 4 columns show the mean and standard deviation for the change in the deposit rate gap (ΔGAP^{ZLB}) and the change in the deposit rate gap without considering zero values for the deposit rate gap (ΔGAP_0^{ZLB}).

Second, Fig. B.1 in Appendix B shows the counterfactual deposit rates when we change the cut-off date between estimation and prediction period from December 2013 to December 2010. Overall, this shows very similar patterns. In some countries (e.g. Austria) the actual deposit rate diverges from the counterfactual from the start of 2014 onwards, whereas actual deposit rates can follow the counterfactual longer in e.g. Spain or, the extreme case, the Netherlands.

Third, we investigate how well our model is able to predict changes in the deposit rate out-of-sample, by splitting the estimation period in two subperiods: the first subperiod covers the pre-crisis period from January 2003 until August 2008, while the second subperiod covers the period between September 2008 (collapse of Lehman Brothers) and December 2013 (end of the estimation period). In this robustness check, Eq. 1 is estimated during this first subperiod, and is subsequently used to forecast out-of-sample changes in the deposit rate in the second subperiod. Columns (1) and (2) in Table 4 show the NRMSE (cf. Eq. 5) for the first and second subperiod, respectively. The NRMSE is only slightly higher for the second subperiod, indicating that the model performs well in forecasting changes in the deposit rate out-of-sample (pre-ZLB). Column (3) of Table 4 displays the NRMSE for the out-of-sample forecasting during the prediction period (January 2014 until December 2019). The NRMSE is a multiple of the NRMSE during the first and second period, which shows the impact of the ZLB: as soon as the rate on household deposits reaches zero, the actual deposit rate can no longer follow the counterfactual path. By comparing Table 2 and Table 4, we find that the NRMSE during the prediction period is especially large for countries with a high deposit rate gap.[24]

$$NRMSE = \frac{1}{\sigma}\sqrt{\frac{\sum_{t=1}^{T}\left(\Delta DepositRate_t^* - \Delta DepositRate_t\right)^2}{T}} \quad (5)$$

Fourth, when discussing the second step, we will also show that our results are robust to, among other things, allowing for an asymmetric reaction of the deposit rate to increases and decreases in the policy rate, as well as to a different number of lags in the first-step regression and an alternative cut-off date.

4.2. Compensating the deposit rate gap on the lending side

In the second step of the analysis, we estimate Eqs. (2)–(4) to investigate whether or not changes in the lending margins that banks charge their retail customers can be explained by the pressure exerted by the ZLB.

In Table 5, the baseline regression in column (1) shows a significantly positive impact of the change in the deposit rate gap on the change in the lending margin. Banks which are constrained by the ZLB on household deposits, i.e. which can no longer decrease their retail deposit rates although they want to do so based on the shadow rate, compensate around 44% of this foregone deposit margin by increasing lending margins. These findings are in line with theoretical predictions by Eggertsson et al. (2019) and Ulate (2021), and empirical work by Eggertsson et al. (2019), Arce et al. (2020) and Basten and Mariathasan (2020) for Sweden, Spain and Switzerland, respectively. In terms of control variables, we observe that increases in household deposits lead to lower lending margins, which can be explained as a supply effect: banks faced with an increase in deposits may decide to increase their loan supply, leading to lower lending margins.

Columns (2) to (9) show the results of the estimation of Eq. 3, in which the change in the deposit rate gap is interacted with several bank (country) characteristics to investigate heterogeneity in the compensation effect. We notice that the aver-

[24] Choosing August 2008 as cut-off date creates two subperiods of similar length: between 62 and 66 months for subperiod 1 (depending on the number of lags included in the regression), 64 months for subperiod 2. The results are robust to using alternative cut-off dates.

Table 3
Deposit betas (and number of lags) for different estimation periods.

	(1)	(2)	(3)	(4)	(5)	(6)
Start date	**01/03**	**01/03**	**01/03**	**01/03**	**01/03**	**01/07**
End date	**12/13**	**12/12**	**12/11**	**12/10**	**12/09**	**12/13**
Austria	0.582 (5)	0.623 (5)	0.641 (5)	0.679 (5)	0.721 (5)	0.528 (4)
Belgium	0.265 (3)	0.259 (2)	0.273 (2)	0.304 (2)	0.348 (3)	0.228 (2)
Germany	0.327 (5)	0.351 (5)	0.360 (5)	0.343 (3)	0.408 (5)	0.301 (4)
Spain	0.291 (3)	0.400 (5)	0.420 (5)	0.456 (5)	0.469 (5)	0.241 (2)
Finland	0.430 (3)	0.465 (3)	0.452 (2)	0.504 (2)	0.521 (2)	0.388 (2)
France	0.346 (7)	0.379 (7)	0.413 (7)	0.417 (7)	0.479 (9)	0.235 (3)
Ireland	0.382 (5)	0.423 (5)	0.421 (5)	0.457 (5)	0.482 (5)	0.362 (3)
Italy	0.196 (5)	0.218 (5)	0.239 (5)	0.256 (5)	0.275 (5)	0.119 (2)
Netherlands	0.192 (5)	0.222 (5)	0.232 (5)	0.250 (5)	0.271 (5)	0.131 (3)
Portugal	0.496 (4)	0.548 (4)	0.511 (3)	0.511 (3)	0.581 (5)	0.432 (3)

This table shows the deposit betas of the first-step regressions for different estimation periods (different start or end date). The deposit betas are calculated as the sum of the β_j coefficients in Eq. 1. The numbers in parentheses are the number of lags (based on the Akaike Information Criterion) of the change in the shadow rate that are included in the estimation.

Table 4
Normalized root mean square error (NRMSE).

	(1)	(2)	(3)
Start date	**01/03**	**09/08**	**01/14**
End date	**08/08**	**12/13**	**12/19**
Austria	0.765	0.852	8.034
Belgium	0.853	1.239	6.620
Germany	0.818	0.879	5.733
Spain	0.845	1.116	5.281
Finland	0.768	0.981	7.119
France	0.897	1.144	3.819
Ireland	0.681	0.939	3.602
Italy	0.822	1.196	1.774
Netherlands	0.942	1.207	2.083
Portugal	0.853	0.955	2.749

This table shows the NRMSE, calculated based on Eq. 5, for three different (sub)periods.

age compensation effect (captured by β_0) remains fairly constant across the different specifications, ranging between 40% and 51%. In line with our hypothesis, we find that banks in countries with higher shares of net interest income, i.e. banks for which the detrimental effect of low-for-long monetary policy is stronger, show more aggressive compensation behaviour. For every percentage point higher share of net interest income (compared to the average in the sample), they compensate 4 percentage points more. The opposite holds for banks with more fee and commission income, as can be seen in column (3). These banks have more alternative income sources besides traditional intermediation activities and are thus less hurt by the ZLB. For every percentage point higher share of fee and commission income, they compensate around 3 percentage points less. While some of the other interactions in columns (4) to (9) indeed show the expected sign (e.g. more compensation in countries with higher bank market power), none of them is statistically significant. Hence, we cannot draw further conclusions about potential heterogeneity between different countries in terms of magnitude of margin compensation. This might also be a result of using a country-level dataset, which limits the analysis to a cross-sectional comparison of 10 countries, thereby ignoring potential within-country heterogeneity.

In Table 6, we perform a first set of robustness tests. Column (1) repeats the estimation of our baseline Eq. 2. In column (2), we estimate Eq. 4 to investigate whether the size of the compensation effect varies over time. A priori, we would expect this compensation effect to become stronger towards the end, because of the increasing pressure of the ZLB. The results suggests that this is indeed the case, with a compensation coefficient that increases both in significance and magnitude (from insignificant to almost 75%) over the years 2014 to 2016. The compensation effect also remains elevated in 2018 and 2019. The exception seems to be 2017, during which the compensation effect is insignificant. This might be explained by the fact that there was no further loosening of monetary policy during the largest part of 2017, coinciding with the economic expansion in the euro area during that year (Rostagno et al., 2021). This implies little changes in the deposit rate gap. Indeed, Fig. 2 shows that the counterfactual deposit rate remained almost flat in every country in 2017. Columns (3) to (6) show what happens when alternative definitions of the dependent variable are used. In column (3), we define the lending margin as the difference between the lending rate and the yield on 5-year government bonds, instead of the 5-year OIS rate. In columns (4) and (5), we use the 10-year OIS rate and 10-year government bond yield instead.[25] Column (6) defines the lending margin

[25] The choice of 10-year rates as an alternative for shorter maturities can be warranted by the fact that we focus on loans for house purchases, which typically have long maturities.

Table 5
Panel estimations of compensation effect.

Dependent var.:	ΔLendingMargin								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔGAP^{ZLB}	0.4383***	0.5119***	0.3993***	0.4422***	0.4406***	0.4377***	0.4251***	0.4638***	0.4717***
	(0.0705)	(0.0450)	(0.0440)	(0.0732)	(0.0781)	(0.0715)	(0.0667)	(0.0968)	(0.0692)
$\Delta GAP^{ZLB} \times$ NII		0.0415***							
		(0.0119)							
$\Delta GAP^{ZLB} \times$ Fee			−0.0332***						
			(0.0072)						
$\Delta GAP^{ZLB} \times$ ROA				0.1655					
				(0.1641)					
$\Delta GAP^{ZLB} \times Deposits^{HH}$					0.0024				
					(0.0116)				
$\Delta GAP^{ZLB} \times$ Capital						0.0012			
						(0.0175)			
$\Delta GAP^{ZLB} \times$ MarketPower							1.7043		
							(1.3220)		
$\Delta GAP^{ZLB} \times$ FloatLoans								−0.0015	
								(0.0029)	
$\Delta GAP^{ZLB} \times D^{GIIPS}$									−0.0904
									(0.1549)
$\Delta Cash_{lag}$	0.0151	0.0153	0.0142	0.0153	0.0151	0.0151	0.0146	0.0151	0.0150
	(0.0093)	(0.0097)	(0.0088)	(0.0094)	(0.0093)	(0.0093)	(0.0090)	(0.0093)	(0.0092)
$\Delta Deposits^{HH}_{lag}$	−0.0104**	−0.0105**	−0.0116**	−0.0106**	−0.0103**	−0.0104**	−0.0105**	−0.0099*	−0.0104**
	(0.0042)	(0.0044)	(0.0041)	(0.0041)	(0.0044)	(0.0042)	(0.0043)	(0.0045)	(0.0042)
ΔCCI_{lag}	−0.0007	−0.0007	−0.0007	−0.0008	−0.0007	−0.0007	−0.0007	−0.0007	−0.0008
	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0019)
ΔExpUnempl	−0.0048	−0.0040	−0.0055	−0.0045	−0.0047	−0.0049	−0.0050	−0.0047	−0.0048
	(0.0078)	(0.0080)	(0.0079)	(0.0078)	(0.0078)	(0.0078)	(0.0079)	(0.0077)	(0.0076)
ΔExpGDPGrowth	−0.0006	0.0014	−0.0014	0.0002	−0.0004	−0.0006	−0.0010	−0.0009	−0.0008
	(0.0055)	(0.0045)	(0.0048)	(0.0052)	(0.0051)	(0.0055)	(0.0055)	(0.0055)	(0.0055)
ΔHPI_{lag}	0.0010	0.0009	0.0005	0.0009	0.0010	0.0010	0.0009	0.0009	0.0009
	(0.0014)	(0.0015)	(0.0015)	(0.0015)	(0.0015)	(0.0014)	(0.0014)	(0.0015)	(0.0015)
LendingMargin	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}
St. errors	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Year	Year	Year	Year	Year	Year	Year	Year	Year
Asymmetry	No	No	No	No	No	No	No	No	No
No. of lags	AIC	AIC	AIC	AIC	AIC	AIC	AIC	AIC	AIC
Start	01/14	01/14	01/14	01/14	01/14	01/14	01/14	01/14	01/14
R^2	0.08	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08
No. of observ.	720	720	720	720	720	720	720	720	720

This table shows the results of the estimation of Eqs. 2 and 3 over the January 2014 until December 2019 period. The numbers in parentheses are standard errors clustered at country level. *, ** and *** indicate significance at 10%, 5% and 1% respectively.

as the lending rate minus a weighted market rate, to correct for the fact that floating rate loans might be priced based on shorter-term market rates.[26] The compensation effect remains highly statistically significant, regardless of the definition of the lending margin, although we observe that defining the lending margin based on longer-term (10-year) market rates causes the compensation effect to increase in magnitude. Overall, the effect ranges from approximately 30% to 80%. In some of these specifications, we also find that increases in house prices are associated with higher lending margins, which shows that banks adequately price increasing risks in their loans. In column (7), we investigate to what extent the changes in the lending margin are driven by changes in the maturity of mortgages. If banks increase mortgage maturities over time, increases in the lending margin might be driven by an increase in the exposure to interest rate risk, instead of a compensation effect. However, adding the change in average mortgage maturity per country as additional control variable does not change the main coefficient of interest. The only notable difference is that the change in the share of household deposits is (borderline) no longer statistically significant.

In the last column of Table 6, we investigate what happens when $GAP^{ZLB}_{c,t}$ is replaced by $GAP_{c,t}$, the difference between the realized and the predicted (counterfactual) deposit rate. We do not use $GAP_{c,t}$ as our baseline explanatory variable, because it might be more prone to reverse causality, since it is based on contemporaneous deposit rate data. However, it has also a very important advantage over the baseline variable. Because the $GAP^{ZLB}_{c,t}$ variable compares the counterfactual deposit rate to zero, it assumes that the ZLB can only start hurting bank profitability if the counterfactual deposit rate reaches zero. However, in a low interest rate environment, deposit margins are already under pressure from ultra-loose monetary policy before

[26] More specifically, the weighted market rate is calculated as a weighted average of the EONIA and the 10-year OIS. The weights in every month are based on the share of floating rate loans in total loans in the previous month.

Table 6
Panel estimations of compensation effect - robustness (1).

Dependent var.:	ΔLendingMargin							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔGAP^{ZLB}	0.4383***		0.4287***	0.7169***	0.8161***	0.2912**	0.4478***	
	(0.0705)		(0.0812)	(0.1039)	(0.1502)	(0.1233)	(0.0751)	
$\Delta GAP^{ZLB} \times D^{2014}$		0.0874						
		(0.1020)						
$\Delta GAP^{ZLB} \times D^{2015}$		0.3343**						
		(0.1201)						
$\Delta GAP^{ZLB} \times D^{2016}$		0.7374***						
		(0.1286)						
$\Delta GAP^{ZLB} \times D^{2017}$		0.0701						
		(0.0592)						
$\Delta GAP^{ZLB} \times D^{2018}$		0.4767***						
		(0.0527)						
$\Delta GAP^{ZLB} \times D^{2019}$		0.5211***						
		(0.1301)						
ΔGAP								0.3678***
								(0.0731)
$\Delta Cash_{lag}$	0.0151	0.0173	0.0173	0.0091	0.0265	0.0066	0.0120	0.0152
	(0.0093)	(0.0105)	(0.0202)	(0.0105)	(0.0237)	(0.0090)	(0.0074)	(0.0093)
$\Delta Deposits^{HH}_{lag}$	−0.0104**	−0.0090*	−0.0126	−0.0192***	−0.0193**	−0.0131	−0.0072	−0.0111**
	(0.0042)	(0.0045)	(0.0110)	(0.0054)	(0.0064)	(0.0089)	(0.0040)	(0.0045)
ΔCCI_{lag}	−0.0007	−0.0006	−0.0004	0.0006	−0.0003	−0.0006	0.0013	−0.0008
	(0.0020)	(0.0019)	(0.0015)	(0.0023)	(0.0018)	(0.0030)	(0.0020)	(0.0020)
ΔExpUnempl	−0.0048	−0.0041	0.0046	−0.0050	0.0009	−0.0057	0.0002	−0.0037
	(0.0078)	(0.0076)	(0.0116)	(0.0075)	(0.0139)	(0.0057)	(0.0070)	(0.0078)
ΔExpGDPGrowth	−0.0006	−0.0036	0.0195	0.0021	0.0298	−0.0034	−0.0076	0.0003
	(0.0055)	(0.0052)	(0.0174)	(0.0104)	(0.0284)	(0.0099)	(0.0066)	(0.0062)
ΔHPI_{lag}	0.0010	0.0010	0.0029	0.0039**	0.0074*	0.0020	0.0017	0.0009
	(0.0014)	(0.0013)	(0.0043)	(0.0016)	(0.0038)	(0.0012)	(0.0016)	(0.0015)
ΔMaturity							0.0003	
							(0.0004)	
LendingMargin	OIS^{5Y}	OIS^{5Y}	GOV^{5Y}	OIS^{10Y}	GOV^{10Y}	Weighted	OIS^{5Y}	OIS^{5Y}
St. errors	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Year	Year	Year	Year	Year	Year	Year	Year
Asymmetry	No	No	No	No	No	No	No	No
No. of lags	AIC	AIC	AIC	AIC	AIC	AIC	AIC	AIC
Start	01/14	01/14	01/14	01/14	01/14	01/14	01/14	01/14
R^2	0.08	0.09	0.07	0.14	0.13	0.05	0.07	0.07
No. of observ.	720	720	720	720	720	720	636	720

This table shows the results of the estimation of Eqs. 2 and 4 over the January 2014 until December 2019 period, with several robustness checks. The numbers in parentheses are standard errors clustered at country level (Cluster), or Driscoll-Kraay (DK) standard errors with default (Stata) lag selection. *, ** and *** indicate significance at 10%, 5% and 1% respectively.

the deposit rate really reaches zero, and this for at least two reasons. First, as shown in Fig. 2, for some countries the actual deposit rate gap seems to be bounded above zero (e.g. France), which might be driven by legal interest rate minima on deposit accounts (e.g. the so-called 'livret A' in France). While our baseline $GAP^{ZLB}_{c,t}$ does not capture this non-zero bound, the $GAP_{c,t}$ does, by allowing a deposit rate gap to occur as soon as the actual deposit rate deviates from the counterfactual, even if this is above zero. Second, banks might be tempted to already decrease deposit rates at a slower pace when approaching the ZLB. Again, the $GAP_{c,t}$ variable is able to capture this phenomenon, because it compares actual and counterfactual deposit rate, instead of only comparing the counterfactual deposit rate with zero. Column (8) in Table 6 shows that the results are very similar when this alternative measure of the deposit rate gap is used.[27]

In Table 7, additional robustness tests are executed. Column (1) repeats the baseline estimation. In column (2), we apply Driscoll-Kraay standard errors, which are commonly used to control for cross-sectional dependence in the data when the time dimension becomes large (Driscoll and Kraay, 1998). We notice that the positive coefficient on the cash ratio becomes significant, implying that increased shares of cash, cash balances at central banks and other demand deposits are associated with higher lending margins. Given that cash reserves are a direct cost for banks when the ECB charges negative deposit rates, this finding is not surprising. The compensation effect remains significant at the 1% significance level. In columns (3) and (4), we omit the year fixed effects and replace the year fixed effects with quarter fixed effects. While the deposit rate gap remains highly statistically significant in both specifications, adding quarter fixed effects takes a lot of variation out of the data and therefore lowers the magnitude of the coefficient. In column (5), we allow deposit rates to react asymmetrically

[27] The correlation between $\Delta GAP^{ZLB}_{c,t}$ and $\Delta GAP_{c,t}$ is 0.89.

Table 7
Panel estimations of compensation effect - robustness (2).

Dependent var.:	ΔLendingMargin							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔGAP^{ZLB}	0.4383***	0.4383***	0.3897***	0.1728**	0.2284*	0.4795***	0.4361***	0.3670***
	(0.0705)	(0.1562)	(0.0659)	(0.0650)	(0.1143)	(0.0677)	(0.0503)	(0.0572)
$\Delta Cash_{lag}$	0.0151	0.0151*	0.0033	0.0045	0.0175	0.0159*	0.0150	0.0123
	(0.0093)	(0.0080)	(0.0063)	(0.0049)	(0.0097)	(0.0085)	(0.0093)	(0.0076)
$\Delta Deposits^{HH}_{lag}$	−0.0104**	−0.0104	−0.0129**	−0.0064	−0.0118**	−0.0104**	−0.0114**	−0.0183**
	(0.0042)	(0.0092)	(0.0046)	(0.0050)	(0.0044)	(0.0042)	(0.0044)	(0.0064)
ΔCCI_{lag}	−0.0007	−0.0007	−0.0012	0.0008	−0.0009	−0.0005	−0.0006	−0.0005
	(0.0020)	(0.0024)	(0.0018)	(0.0022)	(0.0019)	(0.0020)	(0.0020)	(0.0017)
ΔExpUnempl	−0.0048	−0.0048	−0.0061	−0.0067*	−0.0050	−0.0055	−0.0056	−0.0067
	(0.0078)	(0.0093)	(0.0082)	(0.0036)	(0.0076)	(0.0081)	(0.0073)	(0.0069)
ΔExpGDPGrowth	−0.0006	−0.0006	−0.0002	0.0022	−0.0077	−0.0013	−0.0012	−0.0087
	(0.0055)	(0.0130)	(0.0058)	(0.0102)	(0.0075)	(0.0057)	(0.0060)	(0.0053)
ΔHPI_{lag}	0.0010	0.0010	0.0002	−0.0008	0.0005	0.0010	0.0008	0.0049***
	(0.0014)	(0.0036)	(0.0012)	(0.0013)	(0.0018)	(0.0014)	(0.0014)	(0.0012)
LendingMargin	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}
St. errors	Cluster	DK	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Year	Year	No	Quarter	Year	Year	No	Year
Asymmetry	No	No	No	No	Yes	No	No	No
No. of lags	AIC	AIC	AIC	AIC	AIC	BIC	12	AIC
Start	01/14	01/14	01/14	01/14	01/14	01/14	01/14	01/11
R^2	0.08	0.08	0.04	0.32	0.05	0.09	0.08	0.12
No. of observ.	720	720	720	720	720	720	720	1080

This table shows the results of the estimation of Eq. 2 over the January 2014 until December 2019 period (01/14) or the January 2011 until December 2019 period (01/11), with several robustness checks. The numbers in parentheses are standard errors clustered at country level. *, ** and *** indicate significance at 10%, 5% and 1% respectively.

to upward and downward movements of the shadow rate, because the literature has shown that deposit rates are typically more rigid when rates increase. We do so by including a separate dummy which distinguishes months of upward and downward movement in Eq. 1 and we obtain similar results.[28] In column (6), the deposit rate gap is constructed by estimating Eq. 1 with the number of lags based on the Bayesian Information Criterion instead of the Akaike Information Criterion. To construct the deposit rate gap in column (7), 12 lags are chosen to allow for a delayed effect up to 1 year, in line with Drechsler et al. (2021). Neither of these adaptations lead to meaningful changes in the coefficients of interest. Column (8) repeats the analysis with a different cut-off date between estimation and prediction period. In this column, the prediction period starts in January 2011 instead of January 2014. The coefficient on the deposit rate gap remains highly statistically significant.[29]

Finally, we check whether the results are driven by a single country only, by omitting each of the countries one by one and re-estimating Eq. 2. Table B.2 in Appendix B shows that this is not the case.

4.3. Economic magnitude per country

In this subsection, we assess the economic impact of our findings for the 10 euro area countries in this sample. More specifically, we calculate how much higher lending margins were in December 2019, in every country, because of the compensation effect.

Estimating the baseline Eq. 2 provides a β_0 coefficient of 0.4383, as shown in column (1) of Table 5. Thus, banks compensate around 44% of the deposit rate gap by increasing their lending margins. We multiply this β_0 with the country-specific value of the deposit rate gap in December 2019. This gives an estimate of how much banks increased their lending margins over the 2014 to 2019 period to compensate the pressure of the ZLB on household deposits. The impact is depicted by the first (blue) bar for every country in Fig. 3 and ranges between 138 bps for Austria and 6 bps for Italy. The second (red) bar shows what happens when we replace $GAP^{ZLB}_{c,t}$ by $GAP_{c,t}$, our alternative measure for the deposit rate gap. In that case, we multiply the β_0 coefficient of 0.3678 (cf. column (8) of Table 6) with the country-specific value of the deposit rate gap[30] in December 2019. We observe that this alternative approach yields very little differences. Noteworthy is the increase in economic impact for Italy (up to 20 bps), which is due to Italian deposit rates seemingly being bounded at a level above zero, cf. Fig. 2. This can only be captured by the $GAP_{c,t}$ variable, not by $GAP^{ZLB}_{c,t}$.

[28] However, this model seems to suffer from overfitting, because the out-of-sample NRMSE is worse than the NRMSE in the symmetrical model. Moreover, the constants in Eq. 1 are not significantly different from zero in the symmetrical model, as expected, but are significantly positive in the asymmetrical model. Re-estimating the asymmetrical model with constants in Eq. 1 fixed to zero, yields a compensation coefficient of 0.31 (significant at 1%). Re-estimating the symmetrical model with constants in Eq. 1 fixed to zero results in no meaningful changes compared to the baseline. Results available upon request.

[29] Additional alternative cut-off dates have been tested, without meaningful changes.

[30] Defined as $GAP_{c,t}$ instead of $GAP^{ZLB}_{c,t}$.

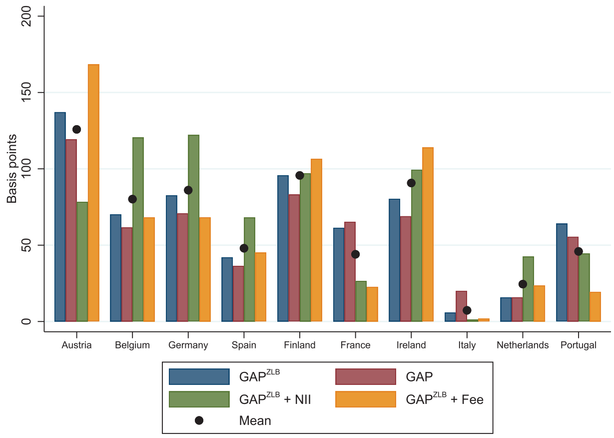

Fig. 3. Economic magnitude of the compensation effect. Country-specific estimates of the increase (in bps) in lending margin as a result of the compensation effect over the January 2014 to December 2019 period, according to 4 different specifications. 'GAP^{ZLB}' refers to the specification in column (1) of Table 5, 'GAP' refers to column (8) of Table 6, 'GAP^{ZLB} + NII' refers to column (2) of Table 5 and 'GAP^{ZLB} + Fee' refers to column (3) of Table 5. 'Mean' is the unweighted mean of the four estimates.

Until now, we assumed that the effect of an increase in the deposit rate gap on the lending margin was homogeneous across countries. However, columns (2) and (3) of Table 5 show that the magnitude of the compensation effect depends on the share of net interest income or fee and commission income. The third (green) and fourth (orange) bar in Fig. 3 illustrate the economic impact if we take this heterogeneity into account. The effect is calculated by combining the β_0 and β_1 coefficient in Eq. 3, as well as every country's end-2013 share of net interest income or fee and commission income, respectively. The black dot in Fig. 3 shows the average effect per country.[31]

According to (the average of) these calculations, by the end of 2019, the ZLB on household deposits had the highest impact in Austria, where the compensation effect pushed lending margins around 126 bps higher, followed by Finland (96 bps), Ireland (91 bps), Germany (86 bps) and Belgium (80 bps).[32] The average effect was markedly lower in Spain (48 bps), Portugal (46 bps), France (44 bps) and the Netherlands (25 bps). There was almost no effect on lending margins in Italy (7 bps). The large difference between Italy and the Netherlands on the one hand, and Austria on the other hand, is not surprising, given the level of the deposit rate in these countries at the start of 2014, cf. our discussion of the counterfactual deposit rate in Section 4.1.

5. Conclusion

By investigating a sample of 10 euro area countries over the January 2003 to December 2019 period, we contribute to the literature regarding the impact of post-GFC (unconventional) monetary policy on banks' net interest margins and lending margins.

After confirming the negative impact of the low-for-long monetary policy environment on euro area banks' net interest margin, in line with findings by, among others, Borio et al. (2017) and Claessens et al. (2018), we investigate the impact of the ZLB on household deposits on bank lending margins. We estimate counterfactual (shadow) deposit rates to capture the hypothetical deposit rate in absence of the ZLB. By comparing these counterfactual deposit rates to the realized deposit rates, we construct country-specific deposit rate gaps, which capture to what extent banks suffer from the ZLB on household deposits. This approach allows to investigate, in a subsequent step, the absolute impact of the ZLB on bank lending margins.

We show that euro area banks which are confronted with increasing deposit rate gaps (partially) compensate by charging higher lending margins on household loans. For each 100 bps increase in the deposit rate gap, banks compensate by adding approximately 44 bps to the lending margin. Moreover, this compensation effect is more pronounced for banks with higher shares of net interest income, while having more fee and commission income operates as a mitigating factor. We quantify the total impact of this compensation effect on the lending margins in the 10 euro area countries in our sample by the end of 2019. The effect is most pronounced in Austria, where it increased bank lending margins by approximately 126 bps. For banks in Italy and the Netherlands the impact was much lower (7 and 25 bps, respectively). For France, Portugal and Spain, the effect is approximately 40 to 50 bps, while the impact on the lending margin is between 80 and 100 bps in Belgium, Germany, Ireland and Finland.

[31] The mean of the four specifications discussed in this subsection.

[32] To put these economic magnitudes into perspective, we calculate the impact of the average increase in mortgage maturity from approximately 22 years to 26 years that we observe over the prediction period. For this purpose, we use the euro area yield curve of the ECB at the end of 2016 (middle of the prediction period). At that point in time, the increase in average mortgage maturity of 4 years corresponds to an increase in interest rates of approximately 9 to 11 bps.

These findings indicate that accommodative monetary policy near the ZLB is less effective compared to a positive interest rate situation. The continued issuance of (T)LTROs at very favourable conditions suggests that the ECB rightfully understands the importance of further alleviating the negative pressure of the low-for-long interest rate environment on banks. Moreover, our results have important implications for bank managers. While they show that banks try to compensate falling (or negative) deposit margins, they indicate that this compensation is only partial. Hence, banks should continue to explore other avenues to improve their profitability, which might include focusing on cost efficiency and functional (revenue) diversification.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Monetary policy and banks' net interest margins

In order to show that our aggregated country-level data adequately capture interest rate dynamics, we confirm earlier results in this research area based on bank-level data. We follow Claessens et al. (2018) and investigate the impact of the short-term interbank rate and yield spread on banks' NIM, by estimating Eq. 6 using our country-level data with monthly frequency.

$$NIM_{c,t} = \alpha_c + \beta_0 NIM_{c,t-1} + \beta_1 EONIA_t + \beta_2 YieldSpread_{c,t} + \sum_{j=1}^{J} \gamma_j CV^j_{c,t} + \epsilon_{c,t} \quad (6)$$

In this specification, $NIM_{c,t}$ is the difference between the monthly lending and deposit rate on new household loans and deposits. As short-term interbank rate, we use the EONIA for all countries. Regarding the yield spread, we either use the difference between the 5-year OIS rate and the EONIA ($YieldSpread^{OIS}_t$) or the difference between the 5-year government bond yield and the EONIA ($YieldSpread^{GOV}_{c,t}$). We estimate a dynamic specification by including a lagged dependent variable. To replicate Claessens et al. (2018), we also include the deposits-to-liabilities ratio, the unweighted capital ratio, the securities-to-assets ratio and GDP growth as control variables ($CV^j_{c,t}$), all at the country level and lagged to mitigate reverse causality. In additional regressions, we also add the (lagged) 5-year sovereign CDS spread as a measure of country-specific risk, as well as (expected) inflation and expected GDP growth to correct for changes in the (expected) macroeconomic environment, following Altavilla et al. (2018). We include country fixed effects to control for unobserved heterogeneity in the cross-section. The very large T dimension avoids inconsistency arising from the inclusion of a lagged dependent variable in the fixed effects estimator (the so-called 'Nickel bias'). Therefore, the use of a System GMM estimator, which is specifically designed to deal with this issue in a small T, large N setting, is not warranted (Arellano and Bover, 1995; Blundell and Bond, 1998). Standard errors are clustered at the country level to correct for correlation within countries over time and heteroskedasticity across countries.

Table A.1 displays the results of the estimation of Eq. 6 over the January 2003 to December 2019 period. In columns (1) to (4), different dynamic specifications are estimated, all including a 1-month lag in the NIM as explanatory variable. Both the coefficient on EONIA and on the yield spread have a significantly positive sign, irrespective of whether the yield spread is constructed using the 5-year OIS rate or the 5-year government bond yield. Hence, the results enable us to confirm the widespread consensus that the low-for-long interest rate environment, which puts downward pressure on the short-term rate and flattens the yield curve, hurts net interest margins (Borio et al., 2017; Claessens et al., 2018; Molyneux et al., 2019). In line with Claessens et al. (2018), we find a significantly positive link between the unweighted capital ratio and the NIM. We also document that banks with more household deposits suffer in terms of the NIM, which might indicate the detrimental impact of the ZLB on deposits, confirming the findings by Heider et al. (2019).

An important remark, however, is that we use monthly instead of yearly data. Hence the NIM_{lag} variable is only lagged by 1 month. To be able to compare our results better to Claessens et al. (2018), we use the 12-month lagged NIM (NIM_{lag12}) as

Table A.1
Panel estimations of the NIM.

Dependent var.:	NIM							
Period:	01/03 - 12/19							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NIM_{lag}	0.9710***	0.9771***	0.9697***	0.9693***				
	(0.0062)	(0.0060)	(0.0063)	(0.0059)				
NIM_{lag12}					0.6681***	0.6981***	0.6782***	0.6821***
					(0.0681)	(0.0662)	(0.0693)	(0.0648)
EONIA	0.0085***	0.0080***	0.0059***	0.0051***	0.1031***	0.1035***	0.0915***	0.0882***
	(0.0018)	(0.0019)	(0.0018)	(0.0015)	(0.0255)	(0.0261)	(0.0222)	(0.0213)
$YieldSpread^{OIS}$	0.0208**		0.0219**		0.0516		0.0705	
	(0.0074)		(0.0072)		(0.0614)		(0.0597)	
$YieldSpread^{GOV}$		0.0055**		0.0228***		0.0299**		0.0776*
		(0.0022)		(0.0055)		(0.0097)		(0.0387)
$Deposits^{HH}_{lag}$	−0.0021**	−0.0015**	−0.0023**	−0.0023**	−0.0158*	−0.0128*	−0.0172*	−0.0170**
	(0.0007)	(0.0006)	(0.0010)	(0.0008)	(0.0074)	(0.0064)	(0.0079)	(0.0070)
$Capital_{lag}$	0.0071***	0.0049***	0.0079***	0.0081***	0.0581**	0.0552***	0.0668***	0.0678***
	(0.0018)	(0.0010)	(0.0021)	(0.0015)	(0.0195)	(0.0150)	(0.0183)	(0.0175)
$Securities_{lag}$	0.0002	0.0000	0.0006	0.0001	0.0058	0.0029	0.0053	0.0034
	(0.0008)	(0.0008)	(0.0007)	(0.0007)	(0.0063)	(0.0071)	(0.0057)	(0.0059)
$GDPGrowth_{lag}$	0.0015*	0.0013	0.0007	0.0008	0.0076	0.0099	−0.0005	0.0000
	(0.0008)	(0.0008)	(0.0010)	(0.0011)	(0.0073)	(0.0075)	(0.0083)	(0.0084)
$Inflation_{lag}$			0.0054	0.0053			−0.0132	−0.0135
			(0.0033)	(0.0033)			(0.0199)	(0.0196)
ExpGDPGrowth			0.0030	0.0029			0.0458	0.0457
			(0.0045)	(0.0045)			(0.0281)	(0.0285)
ExpInflation			0.0041	0.0027			0.1130	0.1083
			(0.0070)	(0.0073)			(0.0625)	(0.0647)
$SovCDS^{5Y}_{lag}$			0.0005	−0.0267***			0.0371*	−0.0546
			(0.0022)	(0.0075)			(0.0170)	(0.0573)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.97	0.97	0.97	0.97	0.67	0.67	0.68	0.69
No. of observ.	2,030	2,030	1,991	1,991	1,920	1,920	1,887	1,887

This table shows the result of dynamic panel regressions of the NIM on the EONIA and the yield spread over the January 2003 until December 2019 period. We include several country-level control variables and country fixed effects. In columns (1) to (4), a 1-month lag of the NIM is included, while columns (5) to (8) include a 12-month lag. The numbers in parentheses are standard errors clustered at country level. *, ** and *** indicate significance at 10%, 5% and 1% respectively.

lagged dependent variable in columns (5) to (8). Unsurprisingly, this causes a drop in the size of the coefficient on this variable, but it leads to little to no changes in the significance of the variables of interest. The only meaningful difference is that the coefficient on the yield spread is sometimes no longer significant, entirely in line with Claessens et al. (2018), who also document a positive but insignificant coefficient in their full sample. Moreover, it should be noted that their sample is much broader (3385 banks from 47 countries) and also includes several developing countries which typically had higher interest rates than the euro area over the last decades. Our results are therefore mostly comparable with the low interest rate subsample of Claessens et al. (2018), in which they find a significantly positive impact of the yield spread on the NIM.

The regression results presented in Table A.1 are obtained by clustering standard errors at the country level. Alternatively, we apply Driscoll-Kraay standard errors to control for cross-sectional dependence in the data (Driscoll and Kraay, 1998). Table A.2 shows that this produces qualitatively similar results. Overall, these findings show that it is possible to replicate well-established results in this research area, which are based on bank-level data, by using our country-level dataset.

Table A.2
Panel estimations of the NIM - Driscoll-Kraay standard errors.

Dependent var.:	NIM							
Period:	01/03 - 12/19							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NIM_{lag}	0.9710***	0.9771***	0.9697***	0.9693***				
	(0.0063)	(0.0064)	(0.0065)	(0.0065)				
NIM_{lag12}					0.6681***	0.6981***	0.6782***	0.6821***
					(0.0431)	(0.0387)	(0.0423)	(0.0405)
EONIA	0.0085***	0.0080***	0.0059**	0.0051**	0.1031***	0.1035***	0.0915***	0.0882***
	(0.0023)	(0.0023)	(0.0024)	(0.0023)	(0.0161)	(0.0162)	(0.0140)	(0.0136)
$YieldSpread^{OIS}$	0.0208***		0.0219***		0.0516*		0.0705**	
	(0.0061)		(0.0051)		(0.0281)		(0.0300)	
$YieldSpread^{GOV}$		0.0055***		0.0228***		0.0299***		0.0776***
		(0.0018)		(0.0045)		(0.0090)		(0.0228)
$Deposits^{HH}_{lag}$	−0.0021**	−0.0015*	−0.0023***	−0.0023***	−0.0158***	−0.0128***	−0.0172***	−0.0170***
	(0.0008)	(0.0008)	(0.0009)	(0.0008)	(0.0042)	(0.0041)	(0.0044)	(0.0044)
$Capital_{lag}$	0.0071***	0.0049***	0.0079***	0.0081***	0.0581***	0.0552***	0.0668***	0.0678***
	(0.0018)	(0.0017)	(0.0019)	(0.0017)	(0.0115)	(0.0102)	(0.0130)	(0.0119)
$Securities_{lag}$	0.0002	0.0000	0.0006	0.0001	0.0058	0.0029	0.0053	0.0034
	(0.0008)	(0.0007)	(0.0008)	(0.0008)	(0.0065)	(0.0062)	(0.0068)	(0.0066)
$GDPGrowth_{lag}$	0.0015	0.0013	0.0007	0.0008	0.0076*	0.0099**	−0.0005	0.0000
	(0.0009)	(0.0009)	(0.0010)	(0.0010)	(0.0040)	(0.0039)	(0.0062)	(0.0057)
$Inflation_{lag}$			0.0054	0.0053*			−0.0132	−0.0135
			(0.0034)	(0.0030)			(0.0162)	(0.0160)
ExpGDPGrowth			0.0030	0.0029			0.0458*	0.0457*
			(0.0042)	(0.0039)			(0.0241)	(0.0237)
ExpInflation			0.0041	0.0027			0.1130***	0.1083***
			(0.0077)	(0.0068)			(0.0372)	(0.0352)
$SovCDS^{5Y}_{lag}$			0.0005	−0.0267***			0.0371***	−0.0546**
			(0.0021)	(0.0053)			(0.0100)	(0.0262)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.97	0.97	0.97	0.97	0.67	0.67	0.68	0.69
No. of observ.	2,030	2,030	1,991	1,991	1,920	1,920	1,887	1,887

This table shows the result of dynamic panel regressions of the NIM on the EONIA and the yield spread over the January 2003 until December 2019 period. We include several country-level control variables and country fixed effects. In columns (1) to (4), a 1-month lag of the NIM is included, while columns (5) to (8) include a 12-month lag. The numbers in parentheses are Driscoll-Kraay standard errors with default (Stata) lag selection. *, ** and *** indicate significance at 10%, 5% and 1% respectively.

Appendix B. Additional tables and figures

Tables B.1 and B.2; Fig. B.1.

Table B.1
Interaction variables.

Variable	NII	Fee	MarketPower	$Deposits^{HH}$	FloatLoans	Capital	ROA
Austria	52.729	21.518	0.318	24.542	82.580	10.692	−0.044
Belgium	64.827	24.895	0.313	30.492	13.350	5.931	0.394
Germany	62.301	26.818	0.217	24.787	17.880	5.812	0.062
Spain	63.796	23.563	0.259	24.243	69.160	13.588	0.359
Finland	57.393	23.047	0.273	15.647	98.180	5.024	0.392
France	51.259	32.835	0.218	15.402	6.650	6.463	0.332
Ireland	59.753	19.006	0.339	8.992	87.220	12.710	−0.876
Italy	49.114	33.518	0.305	22.957	76.640	9.650	−0.769
Netherlands	75.051	18.048	0.299	17.501	21.400	5.110	0.242
Portugal	54.029	33.718	0.287	25.985	91.930	9.966	−0.705
Mean	59.025	25.697	0.283	21.055	56.499	8.495	−0.061

This table shows the end-2013 values for the 7 variables which are used in the interactions in Eq. 3. These variables are demeaned before interacting with $\Delta GAP^{ZLB}_{c,t}$.

Table B.2
Panel estimations of compensation effect - omit countries.

Dependent var.:	ΔLendingMargin										
Omit country:	None	Austria	Belgium	Finland	France	Germany	Ireland	Italy	Netherlands	Portugal	Spain
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
ΔGAP^{ZLB}	0.4383***	0.4309***	0.4046***	0.4313***	0.4635***	0.4322***	0.4077***	0.4506***	0.4319***	0.4909***	0.4308***
	(0.0705)	(0.0903)	(0.0681)	(0.0903)	(0.0706)	(0.0764)	(0.0765)	(0.0706)	(0.0716)	(0.0562)	(0.0761)
$\Delta Cash_{lag}$	0.0151	0.0134	0.0168	0.0364	0.0113	0.0146	0.0145	0.0147	0.0152	0.0156	0.0125
	(0.0093)	(0.0085)	(0.0121)	(0.0202)	(0.0065)	(0.0088)	(0.0091)	(0.0087)	(0.0096)	(0.0102)	(0.0081)
$\Delta Deposits^{HH}_{lag}$	−0.0104**	−0.0077*	−0.0113*	−0.0117	−0.0107**	−0.0117**	−0.0088**	−0.0108**	−0.0090*	−0.0106**	−0.0124**
	(0.0042)	(0.0037)	(0.0056)	(0.0070)	(0.0045)	(0.0043)	(0.0038)	(0.0045)	(0.0042)	(0.0044)	(0.0042)
ΔCCI_{lag}	−0.0007	−0.0003	−0.0009	−0.0008	−0.0004	−0.0006	0.0006	−0.0022	−0.0002	−0.0012	−0.0009
	(0.0020)	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0022)	(0.0013)	(0.0022)	(0.0021)	(0.0022)
ΔExpUnempl	−0.0048	−0.0068	−0.0044	−0.0056	−0.0061	−0.0044	0.0030	−0.0043	−0.0024	−0.0086	−0.0078
	(0.0078)	(0.0077)	(0.0082)	(0.0081)	(0.0078)	(0.0079)	(0.0055)	(0.0081)	(0.0085)	(0.0090)	(0.0085)
ΔExpGDPGrowth	−0.0006	−0.0013	−0.0000	−0.0002	0.0000	−0.0011	−0.0014	−0.0008	−0.0017	−0.0037	0.0045
	(0.0055)	(0.0058)	(0.0058)	(0.0067)	(0.0060)	(0.0056)	(0.0053)	(0.0061)	(0.0076)	(0.0048)	(0.0039)
ΔHPI_{lag}	0.0010	0.0004	0.0010	0.0016	0.0009	0.0005	0.0004	0.0012	0.0009	0.0012	0.0017
	(0.0014)	(0.0014)	(0.0016)	(0.0015)	(0.0014)	(0.0014)	(0.0014)	(0.0019)	(0.0015)	(0.0021)	(0.0014)
LendingMargin	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}
St. errors	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
Asymmetry	No	No	No	No	No	No	No	No	No	No	No
No. of lags	AIC	AIC	AIC	AIC	AIC	AIC	AIC	AIC	AIC	AIC	AIC
Start	01/14	01/14	01/14	01/14	01/14	01/14	01/14	01/14	01/14	01/14	01/14
R^2	0.08	0.07	0.08	0.08	0.09	0.09	0.07	0.09	0.08	0.09	0.08
No. of observ.	720	648	648	648	648	648	648	648	648	648	648

This table shows the results of the estimation of Eq. 2 over the January 2014 until December 2019 period. In columns (2) to (11), all countries are omitted one by one. The numbers in parentheses are standard errors clustered at country level. *, ** and *** indicate significance at 10%, 5% and 1% respectively.

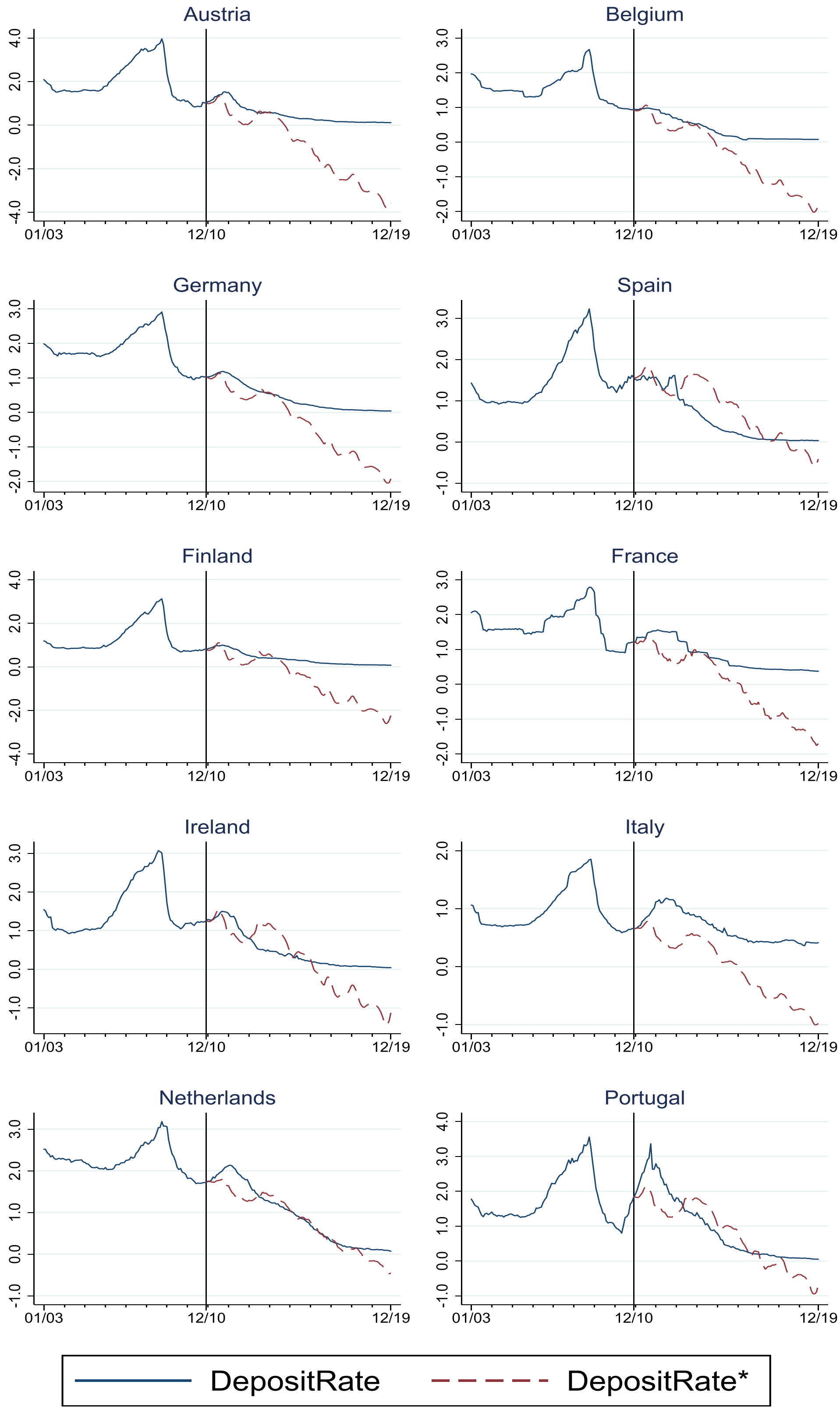

Fig. B.1. Estimation of the counterfactual deposit rate - alternative cut-off date.

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