European bank margins at the zero lower bound

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Abstract

In the post-GFC period, the accommodative monetary policy of the ECB exerts increasing downward pressure on euro area banks' net interest margins. Using monthly data on household lending and deposit rates over the period 2003-2019 in 10 euro area countries, we first confirm that lower policy rates are associated with narrowing bank interest margins. Second, using a shadow rate to capture the stance of unconventional monetary policy, we construct a counterfactual deposit rate in the absence of a zero lower bound and investigate whether or not banks attempt to compensate foregone deposit margins by increasing their lending margins. Our results show a substantial degree of margin compensation (around 40%). This finding has implications for bank profitability, but also for the transmission of monetary policy to bank lending.

Keywords: European banks, interest margin, zero lower bound, lending rate, deposit rate

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1. Introduction

Traditionally, the core function of banking consists in financial intermediation between savers and borrowers (Diamond, 1984). From this intermediation

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activity, banks earn a net interest margin (NIM) which can be split in three components: the yield spread (the difference between the risk-free long-term and short-term interest rate), 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 serious pressure. First of all, 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 all-time 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 protect their intermediation margin. In this paper, we argue that banks try to compensate the declining contribution of the deposit margin, which has even become negative, by increasing their lending margins.

We empirically test 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 deposit rates. As a benchmark rate to predict the counterfactual deposit rate, we use the Wu & Xia (2017) shadow rate which is an extension and adaptation to the euro area of Wu & 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 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 consider zero as a natural lower bound for customer 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 40%. 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 bps[4], banks will increase their

[4]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.

lending markup by around 40 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. Moreover, the results also yield implications for bank managers. Because the compensation effect is only 40%, banks are unable to fully compensate the impact of the ZLB on their NIMs, which calls for increasing focus on cost efficiency and functional (income) 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 paper is firmly situated in the literature examining the determinants of bank interest margins. In their seminal paper, Ho & 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 the margin have been the object of interest in many papers since then. To assess the impact of monetary policy, bank interest margins are typically regressed on a short term money market rate (Claeys & Vander Vennet, 2008; Albertazzi & Gambacorta, 2009) and the yield spread (Entrop et al., 2015; Alessandri & Nelson, 2015). Most papers find a positive coefficient for both factors, although not always significant. More recently, Borio et al. (2017), Claessens et al. (2018), Molyneux et al. (2019) and Argimon et al. (2021) find for broad samples of banks in cross-country panels that lower policy rates as well as a flatting yield curve are associated with lower bank NIMs. We contribute to this literature by confirming the positive relation between the NIM and policy rates using monthly bank interest rates on new business, aggregated at the country-level, rather than using 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 (Illes & Lombardi, 2013; 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 retail deposits (Heider & Leonello, 2021), by increasing their lending margins.

Another strand of the literature analyzes the pass-through of monetary policy rates to bank interest rates. Hofmann & Mizen (2004) provide a theoretical and econometric framework to assess this pass-through. Typically, a cointegrating relationship between money market and bank interest rates is estimated from which the speed and magnitude of the pass-through can be derived. 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) find that there is some asymmetry in upward and downward deposit rate adjustments and that larger deviations from equilibrium mark-ups lead to faster adjustments. Other papers investigating this pass-through include Mojon (2000), Sander & Kleimeier (2004) and van Leuvensteijn et al. (2013).[5] With bank deposit rates close to the ZLB, different papers show a weakening of the pass-through to deposit rates (Eggertsson et al., 2020; Heider et al., 2019; Wang, 2020; Ulate, 2021). Hofmann et al. (2020) analyze the effect of post-2008 unconventional monetary policy on bank interest rates. We contribute to this literature by analyzing the pass-through of (unconventional) monetary policy to banks' deposit pricing and by constructing a counterfactual deposit rate which represents the path of the deposit rate in absence of the ZLB. The gap between the realized and counterfactual deposit rate can be used to assess the impact of the ZLB on banks' lending margins.

[5] Andries & Billon (2016) provide an overview of the literature for the euro area up to 2015.

This paper also contributes to the growing literature on shadow rates as a proxy for the stance of monetary policy. Wu & Zhang (2019) show that shadow rates are a useful summary statistic capturing the impact of unconventional policies, e.g. the negative deposit facility rate, the consecutive asset purchase programs, (T)LTROs and forward guidance. Furthermore, they show that the use of a shadow rate can alleviate structural breaks in a New Keynesian model induced by the ZLB. On a similar line, we estimate an empirical model in which banks set their deposit rates relative to the prevailing shadow rate, thereby estimating a deposit beta following the approach by Drechsler et al. (2021), who calculate a deposit spread beta by regressing the change in the deposit rate on the change in the Federal funds rate. Our contribution is to use the observed bank deposit beta to construct out-of-sample forecasts of a counterfactual (shadow) deposit rate that would have prevailed in the absence of a ZLB on retail deposit rates. We then analyze how this measure of bank constrainedness affects banks' rate adjustment behavior on household loans. We prefer the shadow rate developed in Wu & Xia (2017), because it is calibrated on the time-varying deposit facility rate 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.

Recently, there has been increased attention in the literature to investigate whether negative money market rates have impaired the pass-through of policy rates to bank interest rates. Horvath et al. (2018) argue, using data up to 2016, that negative interest rates do not reduce bank interest rates' responsiveness. In a theoretical model, Brunnermeier & Koby (2019) 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. The existence of a reversal rate is confirmed in Eggertsson et al. (2020). In contrast, other papers such as Ulate

(2021) and Onofri et al. (2021) show that the monetary policy transmission is hampered but can still be expansionary. The same results are obtained in empirical analyses, with Eggertsson et al. (2020) concluding that there is a reversal rate in Sweden and Heider et al. (2019) pointing in the direction of a lessened pass-through in terms of credit supply. We contribute to this literature by investigating whether ultra-loose accommodative monetary policy, which causes retail deposit rates to become constrained by the ZLB, pushes 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 in this paper 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. Data and methodology

3.1. Data

In this paper, we use monthly data for a sample of 10 euro area countries[6] from January 2003 to December 2019. Data on bank interest rates are retrieved from the MFI statistics in the ECB Statistical Data Warehouse (SDW).[7] This

[6]The countries included in the sample are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain. We exclude Greece, because Greek banks defaulted and were rescued by a combination of ELA and capital injections by the HSFS. Moreover, the Greek banking system faced capital controls and deposit withdrawal caps, rendering the analysis of Greek bank margins uninformative.

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

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 as swiftly as possible. For the deposit side, we calculate the rate as a volume-weighted average of 3 different categories with a maturity up to 2 years.[8]

By using country-level SDW data on loans and deposits, we deviate from most existing papers investigating the impact of monetary policy on interest rates and interest 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 using 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 & 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 rate statistics in the SDW are available at monthly frequency since the start of the database in 2003. Second, these data allow us to define an ex-ante (forward-looking) NIM variable as the difference between the

[8]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.

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 best variable to assess the impact of recent changes in monetary policy on bank behaviour.[9] 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.

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 of both rates in Figure 1.

To capture the interest rate environment, we use a number of different benchmarks. For the short end of the yield curve, we include the EONIA. We use either the 5-year OIS rate or the yield on government bonds with 5-year maturity for the long end. As a measure of the (unconventional) monetary policy stance, we use the euro area shadow rate developed in Wu & Xia (2016) and Wu & Xia (2017), which is retrieved from the authors' website. Given the fo-

[9] Therefore, Agapova & 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 paper.

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
$YieldSpread^{OIS}$	OIS^{5Y} – EONIA (%)	REF	2040	0.66	0.55	−0.43	2.15
$YieldSpread^{GOV}$	GOV^{5Y} – EONIA (%)	REF	2040	1.16	1.68	−0.66	17.03
ShadowRate	Shadow rate (%)	WU	1840	−0.81	3.34	−7.82	4.28
Panel C: Bank sector 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
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
$SovCDS^{5Y}$	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 sector 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 & Xia (2017) (WU), the IMF World Economic Outlook (IMF), IHS Markit (IHS) and the European Commission (EC) as displayed in the third column.

cus 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 & 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.[10] These rates are retrieved from Refinitiv and plotted in Figure 1. The summary stats are shown in Panel B of Table 1.

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

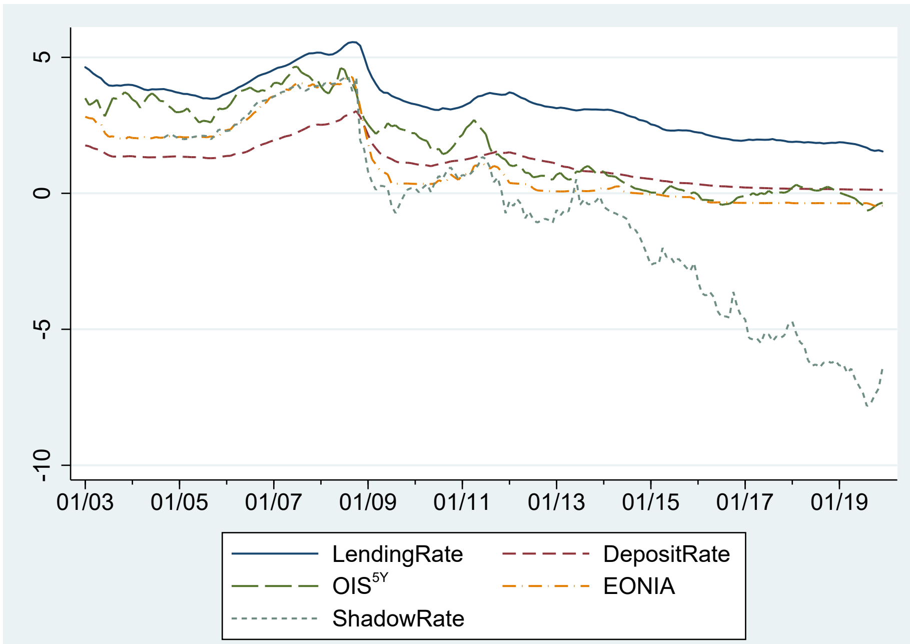

Figure 1: Key euro area interest rates (unweighted average of 10 countries)

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[11] and cash[12] as percentage of total assets are included to control for asset allocation decisions. Differences in countries' economic conditions are captured by GDP growth, inflation, their respective expectations, the consumer confidence index (CCI) and the house price index (HPI) as measures for demand and supply effects and nominal contracting (Claeys & Vander Vennet, 2008; Albertazzi & Gambacorta, 2009; Entrop et al., 2015). As a measure for sovereign risk, we use the 5-year CDS spread on gov-

[11] Consisting of holdings of debt securities, MMF shares/units and equity and non-MMF investment fund shares/units.
[12] Cash, cash balances at central banks and other demand deposits.

ernment 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) and semi-annual (expected GDP growth, expected inflation) 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 6 months, respectively. The bank sector and macroeconomic control 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) only, this is not a concern. The same applies to the HPI, which is only available for all countries from 2010 onwards.

3.2. Methodology

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, as an introductory step, we 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 by estimating Equation 1, using our country-level data with monthly frequency.

$$NIM_{c,t} = \alpha_c + \beta_1 EONIA_t + \beta_2 YieldSpread_{c,t} + \sum_{j=1}^{J} \gamma_j CV_{c,t}^{j} + \epsilon_{c,t} \qquad (1)$$

In this specification, $NIM_{c,t}$ is the difference between the monthly lending and deposit rate on new household loans and deposits, as defined above.

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 ($YieldSpread_t^{OIS}$) or the difference between the 5-year government bond yield and the EONIA ($YieldSpread_{c,t}^{GOV}$). We estimate a dynamic specification by including the lagged dependent variable as a first control 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 ($CV_{c,t}^{j}$), 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 & Bover, 1995; Blundell & Bond, 1998). Standard errors are clustered at the country level to correct for correlation within countries over time and heteroskedasticity across countries.

Next, we proceed to the main contribution of this paper and examine whether banks try to compensate decreasing margins on their deposits by increasing their 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 their 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 the January 2003 (start of the sample) to December 2013 period. 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.[13] In this period, we establish a link between banks' deposit rates and the policy rate during 'normal' times, i.e. with deposit rates not hitting the ZLB yet. These results are used to predict counterfactual deposit rates (assuming no ZLB) in the subsequent prediction period. An important innovation of this paper is that we construct these counterfactual deposit rates based on the Wu & Xia (2017) euro area shadow rate as a measure of the monetary policy stance. By using the 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 deposit facility rate (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 on deposit rates. Moreover, banks commonly use replicating portfolio models, typically with maturities up to 10 years, to estimate the duration of their non-maturing deposit funding and to hedge their interest rate sensitivity accordingly (Kalkbrener & Willing, 2004). Hence, using shadow rates which

[13]For robustness checks on this cut-off date, cf. Section 4.2.

capture the yield curve dynamics up to 10 year to forecast (counterfactual) deposit rates can serve as a reasonable approximation of these models.

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 Drechsler et al. (2021) and run the following time series regression for each country during the estimation period:[14]

$$\Delta DepositRate_t = \alpha_0 + \sum_{j=0}^{J} \beta_j \Delta ShadowRate_{t-j} + \epsilon_t \tag{2}$$

Based on Equation 2, 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.

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 two variables to measure the degree to which the ZLB hurts banks in different countries:

$$\begin{aligned} GAP_{c,t} &= DepositRate_{c,t} - DepositRate^*_{c,t} \\ &\quad \text{if } DepositRate^*_{c,t} < DepositRate_{c,t}; \quad 0 \text{ otherwise.} \\ GAP^{ZLB}_{c,t} &= |DepositRate^*_{c,t}| \\ &\quad \text{if } DepositRate^*_{c,t} < 0; \quad 0 \text{ otherwise.} \end{aligned}$$

As the positive difference between the realized deposit rate and the counterfactual deposit rate in absence of the ZLB, the $GAP_{c,t}$ variable is a straightfor-

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

ward measure of the degree to which the ZLB on retail deposits hurts banks. A disadvantage of this measure, however, is that it 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 $GAP_{c,t}^{ZLB}$ as main variable of interest in this analysis. 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 deposit rate is not impacted by the ZLB and can continue its downward movement. Hence the deposit rate gap will widen, which is captured by the $GAP_{c,t}^{ZLB}$. The advantage is that this variable does not use contemporaneous data[15], making reverse causality less likely.

To investigate potential compensation effects by banks, we assume that banks price loans as a spread above the prevailing market rate (e.g. 5-year OIS rate). 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 might also be used by banks to compensate for falling deposit margins. In a panel covering the prediction period, we run the Equation 3 to test this compensation hypothesis. As the deposit rate gap is non-stationary, we estimate a model in first differences to avoid spurious regression problems.[16]

$$\Delta LendingMargin_{c,t} = \alpha_c + \eta_t + \beta_0 \Delta GAP_{c,t}^{ZLB} + \sum_{j=1}^{J} \gamma_j CV_{c,t}^{j} + \epsilon_{c,t} \quad (3)$$

[15]Except for the contemporaneous shadow rate, but this variable is constructed at the level of the euro area, not the individual country-level.

[16]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.

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 risk. 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, respectively. Standard errors are clustered at the country level.

Additionally, we investigate whether the compensation effect varies over time by including interactions between the change in the deposit rate gap and the year dummies, as shown in Equation 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.

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

Furthermore, banks' ability or necessity to compensate the pressure of the ZLB on household deposits might depend on their market power, their share of household deposits, the percentage of loans issued with floating (variable) rates and their (unweighted) capital ratio. Therefore, we also add interactions between the change in the deposit rate gap and the dummies D^i, with $i = \{\text{MarketPower, DepositsHH, FloatLoans, Capital, Tier1}\}$, as shown in Equation 5. These dummies are equal to 1 for the five countries with above median market power[17], share of household deposits in total liabilities[18], share of floating rate loans in total loans for house purchases[19], unweighted capital ratio[20] and Tier1 capital ratio[21], respectively. All dummies are based on pre-prediction period (i.e. end-2013) values.

$$\begin{aligned}\Delta LendingMargin_{c,t} = \alpha_c + \eta_t + \beta_0 \Delta GAP^{ZLB}_{c,t} \\ + \beta_1(\Delta GAP^{ZLB}_{c,t} \times D^i) + \sum_{j=1}^{J} \gamma_j CV^j_{c,t} + \epsilon_{c,t} \qquad (5)\end{aligned}$$

[17] Obtained from Coccorese et al. (2021). Dummy equal to 1 for Austria, Belgium, Ireland, Italy, Netherlands.

[18] Obtained from SDW. Dummy equal to 1 for Austria, Belgium, Germany, Portugal, Spain.

[19] Obtained from SDW. Dummy equal to 1 for Austria, Finland, Ireland, Italy, Portugal.

[20] Obtained from SDW. Dummy equal to 1 for Austria, Ireland, Italy, Portugal, Spain.

[21] Obtained from SDW. Dummy equal to 1 for Belgium, Finland, France, Germany, Ireland.

4. Results

4.1. Monetary policy and banks' net interest margins

In this subsection, we show that our country-level data are of sufficient granularity to capture relevant interest rate dynamics in the euro area banking sector. More specifically, we investigate the impact of monetary policy on banks' net interest margins, replicating the main results of Claessens et al. (2018) with our dataset.

Table 2: 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)
LagTenYCDS								
$SovCDS^{5Y}_{lag}$			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	0.9729	0.9727	0.9731	0.9734	0.6667	0.6702	0.6829	0.6874
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)-(4), a 1-month lag of the NIM is included, while columns (5)-(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.

Table 2 displays the results of the estimation of Equation 1 over the January 2003 to December 2019 period. In columns (1)-(4), different dynamic specifications are estimated, all including a 1-month lag in the NIM as explanatory variable. In (1)-(4), both the EONIA and 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) and Freriks & Kakes (2021).

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 lagged dependent variable in columns (5)-(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. Our results are also very similar to the results obtained in Box 5 in ECB (2015), which documents a positive relationship between euro area banks' NIM and the short-term interest rate and slope of the yield curve over the 1994-2014 period.

The regression results presented in Table 2 are obtained by clustering standard errors at the country level. Alternatively, 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 & Kraay, 1998). Table A.1 in the appendix shows that this produces qualitatively similar results.

4.2. Compensating the deposit rate gap at the ZLB

In this subsection, we analyze whether banks try to compensate the pressure of the ZLB on retail deposits by increasing their lending margins.

In a first step, we construct counterfactual deposit rates per country. These shadow deposit rates depict the path that deposit rates would have followed in absence of the ZLB. We first estimate, for every country separately, Equation 2 in the estimation period. The coefficients obtained from these regressions are subsequently used to predict (out-of-sample) the counterfactual deposit rate in the prediction period, i.e. from January 2014 onwards. Figure 2 shows the resulting counterfactual deposit rate (DepositRate*) per country and how it deviates from the realized (actual) deposit rate. Three broad categories of countries can be distinguished. In a first subset (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, we have a country like the Netherlands, where 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 estimated counterfactual, until the end

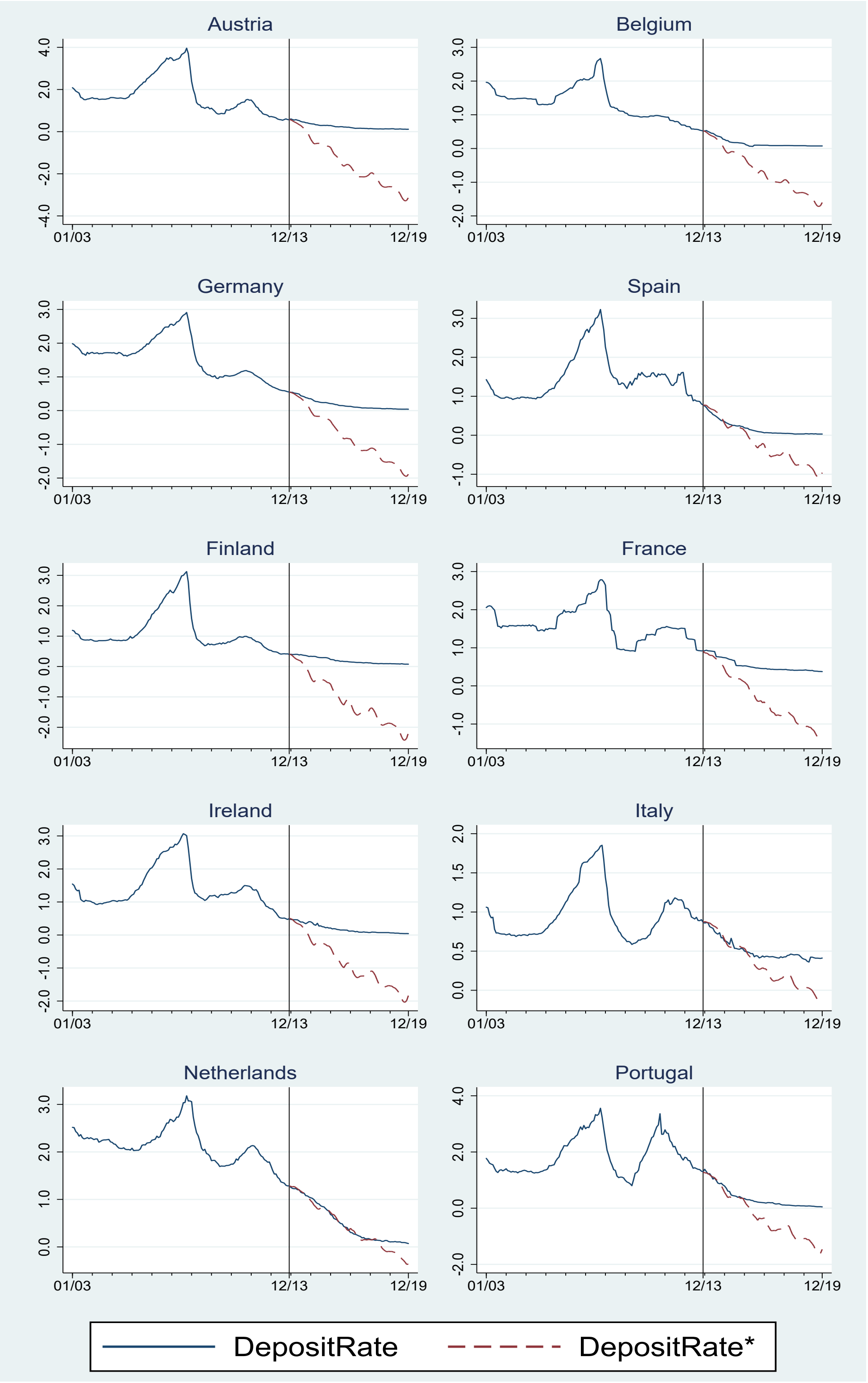

Figure 2: Estimation of the counterfactual deposit rate

Table 3: Descriptive statistics of the deposit rate gap

Variable Statistic	$\mathbf{GAP^{ZLB}}$ **Mean**	$\mathbf{GAP^{ZLB}}$ **SD**	$\mathbf{GAP^{ZLB}}$ **Max**	$\mathbf{GAP^{ZLB}}$ **Months**	$\mathbf{\Delta GAP^{ZLB}}$ **Mean**	$\mathbf{\Delta GAP^{ZLB}}$ **SD**	$\mathbf{\Delta GAP_0^{ZLB}}$ **Mean**	$\mathbf{\Delta GAP_0^{ZLB}}$ **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 ($\mathrm{GAP^{ZLB}}$) 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 ($\Delta\mathrm{GAP^{ZLB}}$) and the change in the deposit rate gap without considering zero values for the deposit rate gap ($\Delta\mathrm{GAP_0^{ZLB}}$).

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 for these countries. We use this deposit rate gap ($GAP_{c,t}^{ZLB}$) as a measure of the impact of the ZLB. Table 3 shows the summary statistics for the deposit rate gap.

Given the importance of this variable for the remainder of the analysis, we perform ample robustness to ensure that the deposit rate gap does not depend on the definition of the estimation period or choices in the specification of Equation 2. First, Table 4 gives an overview of the country-specific deposit betas, calculated as the sum of the β_j coefficients in Equation 2, in line with Drechsler et al. (2021) who use these deposit betas as an indication of the pass-through of policy rates to deposit rates. Column (1) shows the deposit betas for the baseline estimation period (January 2003 until December 2013), whereas columns (2)-(6) show the results for alternative choices of the estimation period. Changing the estimation period does not cause the deposit betas to change meaningfully.

Table 4: 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 estimated 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 Equation 2. 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.

Second, Figure A.1 in the Appendix shows the counterfactual deposit rates when we change the cut-off date between estimation and prediction period to December 2010. Overall, this shows very similar patterns compared to the baseline scenario with cut-off date on December 2013: 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 other countries (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, Equation 2 is estimated during this first subperiod, and is subsequently used to forecast changes in the deposit rate in the second subperiod. Columns (1)-(2) in Table 5 show the normalized root

Table 5: Normalized root mean square error

	(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 normalized root mean square error, calculated based on Equation 6, for three different (sub)periods.

mean square error (NRMSE, cf. Equation 6) 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). Additionally, column (3) of Table 5 displays the NRMSE for the out-of-sample forecasting during the prediction period (January 2014 until December 2019). The NRMSE during this period 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. Moreover, by comparing Table 3 and Table 5, we find that the NRMSE during the prediction period is especially large for countries with a high deposit rate gap.[22]

$$NRMSE = \frac{1}{\sigma}\sqrt{\frac{\sum_{t=1}^{T}(\Delta DepositRate_t^* - \Delta DepositRate_t)^2}{T}} \tag{6}$$

[22] 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.

Fourth, when discussing the second step (cf. infra), 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.

In the second step of the analysis, we estimate Equation 3, 4 and 5 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 on retail deposits. Table 6 contains the results of this analysis. 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. More specifically, banks which are constrained by the ZLB on deposits, i.e. who 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 on the lending side by increasing their lending margins.

A priori, we would expect this compensation effect to become stronger towards the end of the sample period, because of the increasing pressure of the ZLB. Column (2) 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., 2019). This implies little to no changes in the deposit rate gap variable. Indeed, Figure 2 shows that the counterfactual deposit rate remained almost flat in every country in 2017.

Table 6: Panel estimations of compensation effect

Dependent var.:	ΔLendingMargin						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔGAP^{ZLB}	0.4383***		0.3552***	0.4103***	0.5705***	0.4846***	0.3745***
	(0.0705)		(0.0905)	(0.0818)	(0.1524)	(0.1029)	(0.1137)
$\Delta GAP^{ZLB} \times D^{2014}$		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)					
$\Delta GAP^{ZLB} \times D^{MarketPower}$			0.1810				
			(0.1246)				
$\Delta GAP^{ZLB} \times D^{DepositsHH}$				0.0510			
				(0.1355)			
$\Delta GAP^{ZLB} \times D^{FloatLoans}$					-0.1811		
					(0.1681)		
$\Delta GAP^{ZLB} \times D^{Capital}$						-0.0791	
						(0.1360)	
$\Delta GAP^{ZLB} \times D^{Tier1}$							0.1116
							(0.1389)
$\Delta Cash_{lag}$	0.0151	0.0173	0.0144	0.0151	0.0154	0.0151	0.0149
	(0.0093)	(0.0105)	(0.0088)	(0.0094)	(0.0095)	(0.0093)	(0.0092)
$\Delta Deposits^{HH}_{lag}$	-0.0104**	-0.0090*	-0.0103**	-0.0102**	-0.0099*	-0.0104**	-0.0104**
	(0.0042)	(0.0045)	(0.0043)	(0.0044)	(0.0044)	(0.0042)	(0.0043)
ΔCCI_{lag}	-0.0007	-0.0006	-0.0008	-0.0007	-0.0007	-0.0007	-0.0007
	(0.0020)	(0.0019)	(0.0020)	(0.0020)	(0.0020)	(0.0020)	(0.0020)
ΔExpUnempl	-0.0048	-0.0041	-0.0051	-0.0048	-0.0044	-0.0047	-0.0050
	(0.0078)	(0.0076)	(0.0078)	(0.0078)	(0.0078)	(0.0077)	(0.0079)
ΔExpGDPGrowth	-0.0006	-0.0036	-0.0019	-0.0004	-0.0003	-0.0006	-0.0015
	(0.0055)	(0.0052)	(0.0054)	(0.0052)	(0.0051)	(0.0056)	(0.0051)
ΔHPI_{lag}	0.0010	0.0010	0.0008	0.0010	0.0009	0.0009	0.0009
	(0.0014)	(0.0013)	(0.0014)	(0.0015)	(0.0015)	(0.0015)	(0.0015)
LendingMargin	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}	OIS^{5Y}
St. errors	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Year	Year	Year	Year	Year	Year	Year
Asymmetry	No	No	No	No	No	No	No
No. of lags	AIC	AIC	AIC	AIC	AIC	AIC	AIC
Start	01/14	01/14	01/14	01/14	01/14	01/14	01/14
R^2	0.0798	0.0916	0.0815	0.0800	0.0812	0.0802	0.0805
No. of observ.	720	720	720	720	720	720	720

This table shows the results of the estimation of Equations 3, 4 and 5 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.

Columns (3)-(7) show the results of the estimation of Equation 5, in which the change in the deposit rate gap is interacted with several dummy variables. While some of these interactions indeed show the expected sign (e.g. more compensation in countries with higher bank market power), none of the effects is statistically significant. Hence, we cannot draw any conclusions about potential heterogeneity between different countries in the magnitude of margin compensation. This might be a result of using a country-level dataset, which limits the analysis to a comparison of five above- and five below-median countries, thereby ignoring potential within-country heterogeneity.

In terms of control variables, we see that increases in household deposits lead to lower lending margins, which can be explained as a supply effect: banks which are faced with an increase in deposits may decide to increase their loan supply, leading to lower lending margins.

Table 7: Panel estimations of compensation effect - robustness (1)

Dependent var.:	ΔLendingMargin						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔGAP^{ZLB}	0.4383***		0.4287***	0.7169***	0.8161***	0.2912**	0.4383***
	(0.0705)		(0.0812)	(0.1039)	(0.1502)	(0.1233)	(0.1562)
ΔGAP		0.3678***					
		(0.0731)					
$\Delta Cash_{lag}$	0.0151	0.0152	0.0173	0.0091	0.0265	0.0066	0.0151*
	(0.0093)	(0.0093)	(0.0202)	(0.0105)	(0.0237)	(0.0090)	(0.0080)
$\Delta Deposits_{lag}^{HH}$	-0.0104**	-0.0111**	-0.0126	-0.0192***	-0.0193**	-0.0131	-0.0104
	(0.0042)	(0.0045)	(0.0110)	(0.0054)	(0.0064)	(0.0089)	(0.0092)
ΔCCI_{lag}	-0.0007	-0.0008	-0.0004	0.0006	-0.0003	-0.0006	-0.0007
	(0.0020)	(0.0020)	(0.0015)	(0.0023)	(0.0018)	(0.0030)	(0.0024)
ΔExpUnempl	-0.0048	-0.0037	0.0046	-0.0050	0.0009	-0.0057	-0.0048
	(0.0078)	(0.0078)	(0.0116)	(0.0075)	(0.0139)	(0.0057)	(0.0093)
ΔExpGDPGrowth	-0.0006	0.0003	0.0195	0.0021	0.0298	-0.0034	-0.0006
	(0.0055)	(0.0062)	(0.0174)	(0.0104)	(0.0284)	(0.0099)	(0.0130)
ΔHPI_{lag}	0.0010	0.0009	0.0029	0.0039**	0.0074*	0.0020	0.0010
	(0.0014)	(0.0015)	(0.0043)	(0.0016)	(0.0038)	(0.0012)	(0.0036)
LendingMargin	OIS^{5Y}	OIS^{5Y}	GOV^{5Y}	OIS^{10Y}	GOV^{10Y}	Weighted	OIS^{5Y}
St. errors	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	DK
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Year	Year	Year	Year	Year	Year	Year
Asymmetry	No	No	No	No	No	No	No
No. of lags	AIC	AIC	AIC	AIC	AIC	AIC	AIC
Start	01/14	01/14	01/14	01/14	01/14	01/14	01/14
R^2	0.0798	0.0722	0.0683	0.1437	0.1343	0.0526	0.0798
No. of observ.	720	720	720	720	720	720	720

This table shows the results of the estimation of Equation 3 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.

In Tables 7 and 8, we perform a number of robustness tests. In both Tables, column (1) repeats the estimation of our baseline Equation 3. Column (2) in Ta-

Table 8: Panel estimations of compensation effect - robustness (2)

Dependent var.:	ΔLendingMargin						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔGAP^{ZLB}	0.4383***	0.3897***	0.1728**	0.2284*	0.4795***	0.4361***	0.3670***
	(0.0705)	(0.0659)	(0.0650)	(0.1143)	(0.0677)	(0.0503)	(0.0572)
$\Delta Cash_{lag}$	0.0151	0.0033	0.0045	0.0175	0.0159*	0.0150	0.0123
	(0.0093)	(0.0063)	(0.0049)	(0.0097)	(0.0085)	(0.0093)	(0.0076)
$\Delta Deposits^{HH}_{lag}$	-0.0104**	-0.0129**	-0.0064	-0.0118**	-0.0104**	-0.0114**	-0.0183**
	(0.0042)	(0.0046)	(0.0050)	(0.0044)	(0.0042)	(0.0044)	(0.0064)
ΔCCI_{lag}	-0.0007	-0.0012	0.0008	-0.0009	-0.0005	-0.0006	-0.0005
	(0.0020)	(0.0018)	(0.0022)	(0.0019)	(0.0020)	(0.0020)	(0.0017)
ΔExpUnempl	-0.0048	-0.0061	-0.0067*	-0.0050	-0.0055	-0.0056	-0.0067
	(0.0078)	(0.0082)	(0.0036)	(0.0076)	(0.0081)	(0.0073)	(0.0069)
ΔExpGDPGrowth	-0.0006	-0.0002	0.0022	-0.0077	-0.0013	-0.0012	-0.0087
	(0.0055)	(0.0058)	(0.0102)	(0.0075)	(0.0057)	(0.0060)	(0.0053)
ΔHPI_{lag}	0.0010	0.0002	-0.0008	0.0005	0.0010	0.0008	0.0049***
	(0.0014)	(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}
St. errors	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Year	No	Quarter	Year	Year	Year	Year
Asymmetry	No	No	No	Yes	No	No	No
No. of lags	AIC	AIC	AIC	AIC	BIC	12	AIC
Start	01/14	01/14	01/14	01/14	01/14	01/14	01/11
R^2	0.0798	0.0390	0.3184	0.0511	0.0907	0.0805	0.1249
No. of observ.	720	720	720	720	720	720	1080

This table shows the results of the estimation of Equation 3 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.

ble 7 shows what happens when $GAP^{ZLB}_{c,t}$ is replaced by $GAP_{c,t}$, the difference between the realized and the predicted (counterfactual) deposit rate. Although the latter might be more prone to reverse causality, it may also capture the actual deposit rate gap better, because it allows a gap to occur already before the deposit rate really hits the ZLB.[23] The results are very similar. Columns (3)-(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)-(5), we use the 10-year OIS rate and 10-year government

[23]Banks might feel the pressure of the ZLB before really hitting zero, for instance because of regulatory minima on deposit accounts. Moreover, banks might already be tempted to decrease their deposit rates at a slower pace when approaching the ZLB.

bond yield instead.[24] Column (6) defines the lending margin 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.[25] 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 correct for increasing risks when pricing their loans. Applying Driscoll-Kraay standard errors to control for cross-sectional dependence in the data does not change the main results either, as can be seen in column (7). We do 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. Columns (2)-(3) of Table 8 repeat the baseline equation, but without the year fixed effects and with quarter fixed effects, respectively. 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 (4), we allow deposit rates to react asymmetrically to upward and downward movements of the shadow rate, because the literature has shown that deposit rates are typically more rigid

[24]The choice of 10-year rates instead of shorter maturities can be warranted by the fact that this paper focuses on loans for house purchases, which typically have rather long maturities. Indeed, the average maturity of mortgages in the euro area is around 20 years. See for example Chart A.1 in ECB (2020).

[25]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.

when market rates increase. We do so by including a separate dummy which distinguishes months of upward and downward movement in Equation 2 and we obtain similar results. In column (5), the deposit rate gap is constructed by estimating Equation 2 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 (6), 12 lags are chosen by default 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 (7) 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.[26] 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 Equation 3. Table A.2 in the Appendix shows that this is not the case.

5. Conclusion

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

First, we examine the relationship between the short-term interbank rate (EONIA), the yield spread and the net interest margin. We confirm 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).

[26]Additional alternative cut-off dates have also been tested. They imply no meaningful changes. Results available upon request.

Second, we investigate the impact of the ZLB on household deposits for 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 retail deposits on bank lending margins. We show that euro area banks faced by increasing deposit rate gaps (partially) compensate by charging higher lending margins on household loans, even after correcting for changes in the riskiness of the loans. For each 100 bps increase in the deposit rate gap, banks compensate by adding approximately 40 bps to the lending margin.

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 indicates 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 (income) diversification.

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Appendix

Table A.1: 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)
LagTenYCDS								
$SovCDS^{5Y}_{lag}$			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	0.9729	0.9727	0.9731	0.9734	0.6667	0.6702	0.6829	0.6874
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)-(4), a 1-month lag of the NIM is included, while columns (5)-(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.

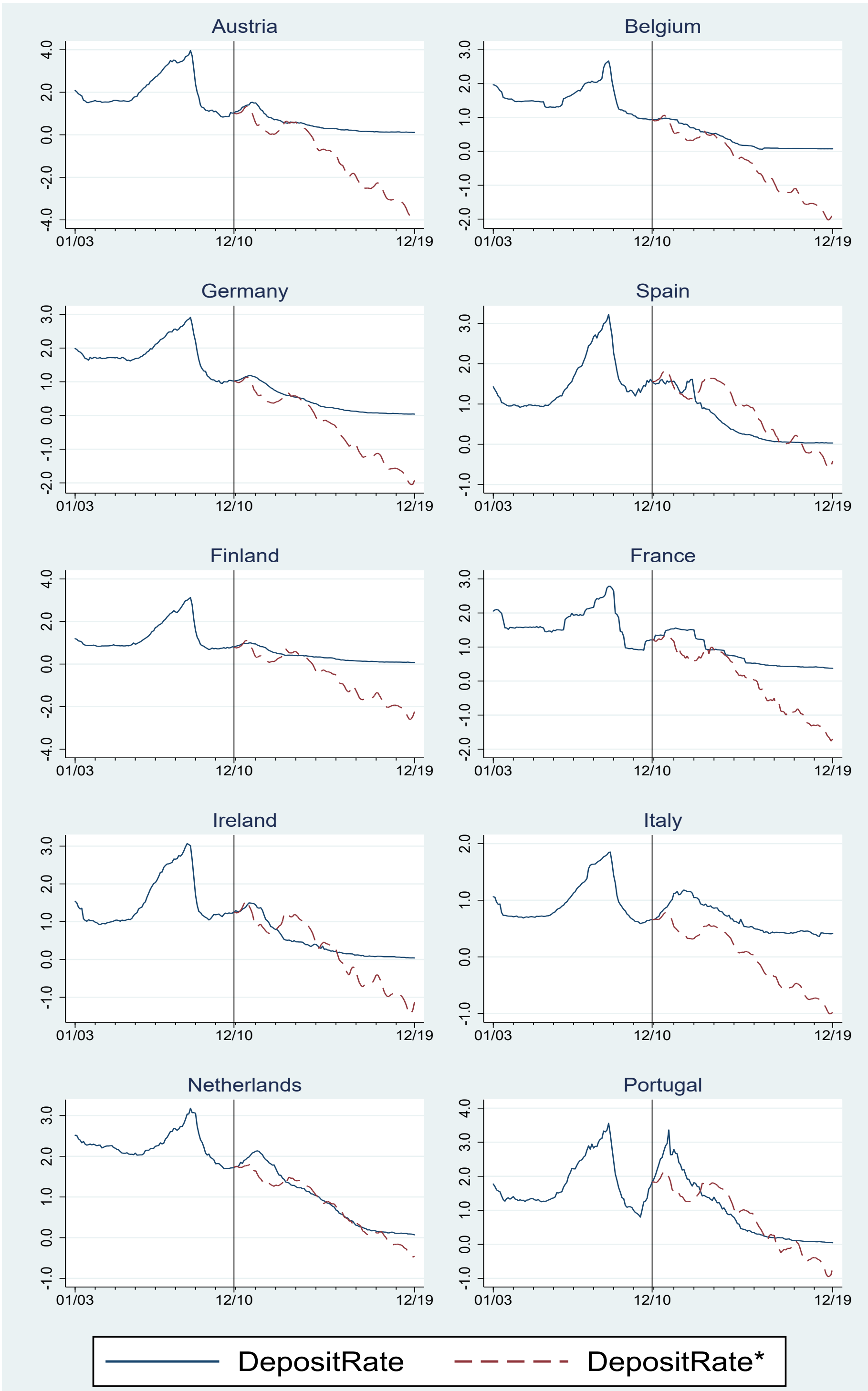

Figure A.1: Estimation of the counterfactual deposit rate - alternative cut-off date

Table A.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)
$\Delta Deposits_{lag}^{HH}$	-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	0.0798	0.0719	0.0777	0.0751	0.0850	0.0858	0.0694	0.0917	0.0843	0.0858	0.0831
No. of observ.	720	648	648	648	648	648	648	648	648	648	648

This table shows the results of the estimation of Equation 3 over the January 2014 until December 2019 period. In columns (2)-(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.