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ABSTRACT/RESUMÉ

Negative interest rates in the euro area: does it hurt banks?

The negative interest rate policy (NIRP) has been in place in the euro area since June 2014. While the NIRP can provide additional monetary accommodation in the situation where the neutral rate of interest is most likely negative, there are also unintended consequences for banks' profitability and potential financial stability risks associated with this policy. The paper assesses the effect of the NIRP on the net interest rate margins of the euro area banks using quarterly consolidated bank level data for some 50 banking groups directly supervised by the Single Supervisory Mechanism. Since our data set extends to 2018, it allows us to examine the period of negative short-term interest rates separately from the period of low, but positive policy rates. The econometric results confirm the effect of the interest rate level on bank profitability and, in some specifications, also suggest an additional negative effect on bank profitability in the period of negative euro area short-term interest rates. This additional effect of the NIRP is the strongest when looking at the disaggregated components of net interest income, i.e. interest income and interest expense. However, the effects are not particularly robust across various profitability measures and tend to disappear when conditioning on macroeconomic variables, such as expected real GDP growth and inflation expectations. Therefore, in line with other existing studies, we find weak evidence of possible negative effects on bank profitability from keeping rates low for an extended period of time. Statistical analysis of the bank-level data also points to an ongoing compression of non-interest income, in particular for the best performing banks, and a slow recovery in return on total assets among all banks over the analysed period.

This Working Paper relates to the 2018 *OECD Economic Survey of Euro Area* (https://www.oecd.org/economy/euro-area-and-european-union-economic-snapshot/)

JEL classification: E43; E52; E58; G21; G28.
Keywords: negative rates, monetary policy, lower bound, bank profitability.

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Taux d'intérêt négatifs dans la zone euro: les banques en souffrent-elles?

La politique de taux d'intérêt négatif (PTIN) est en place dans la zone euro depuis juin 2014. Bien que la PTIN puisse fournir un assouplissement monétaire supplémentaire dans une situation où le taux d'intérêt neutre est très probablement négatif, il y a aussi des conséquences imprévues sur la rentabilité des banques et des risques potentiels pour la stabilité financière associés à cette politique. Le document évalue l'effet de la PTIN sur les marges nettes d'intérêt des banques de la zone euro en utilisant des données trimestrielles consolidées au niveau des banques pour une cinquantaine de groupes bancaires directement contrôlés par le mécanisme de surveillance unique. Comme notre ensemble de données s'étend jusqu'en 2018, il nous permet d'examiner la période de taux d'intérêt négatifs à court terme en la dissociant de la période de taux directeurs bas, mais positifs.

Les résultats économétriques confirment l'effet du niveau des taux d'intérêt sur la rentabilité des banques et, dans certaines spécifications, suggèrent également un effet négatif supplémentaire sur la rentabilité des banques durant la période de taux d'intérêt négatifs à court terme dans la zone euro. Cet effet supplémentaire de la PTIN est le plus important lorsqu'on examine les composantes désagrégées du revenu net d'intérêt, c'est-à-dire le revenu d'intérêt et les intérêts débiteurs. Toutefois, les effets ne sont pas particulièrement robustes pour les diverses mesures de rentabilité et ont tendance à disparaître lorsque sont prises en compte des variables macroéconomiques, comme la croissance attendue du PIB réel et les anticipations d'inflation. Par conséquent, à l'instar d'autres études existantes, nous trouvons peu d'éléments indiquant que le maintien des taux bas pendant une longue période pourrait avoir des effets négatifs sur la rentabilité des banques. L'analyse statistique des données au niveau des banques fait également apparaître une compression continue des revenus autres que d'intérêts, en particulier pour les banques les plus performantes, et une lente reprise du rendement de l'actif total parmi toutes les banques sur la période analysée.

Ce Document de travail se rapporte à l'Etude économique de l'OCDE de la Zone Euro 2018 (https://www.oecd.org/fr/economie/union-europeenne-zone-euro-en-un-coup-d-oeil/)

Classification JEL: E43; E52; E58; G21; G28.
Mots clefs : taux d'intérêt négatifs, politique monétaire, taux plancher, rentabilité bancaire.

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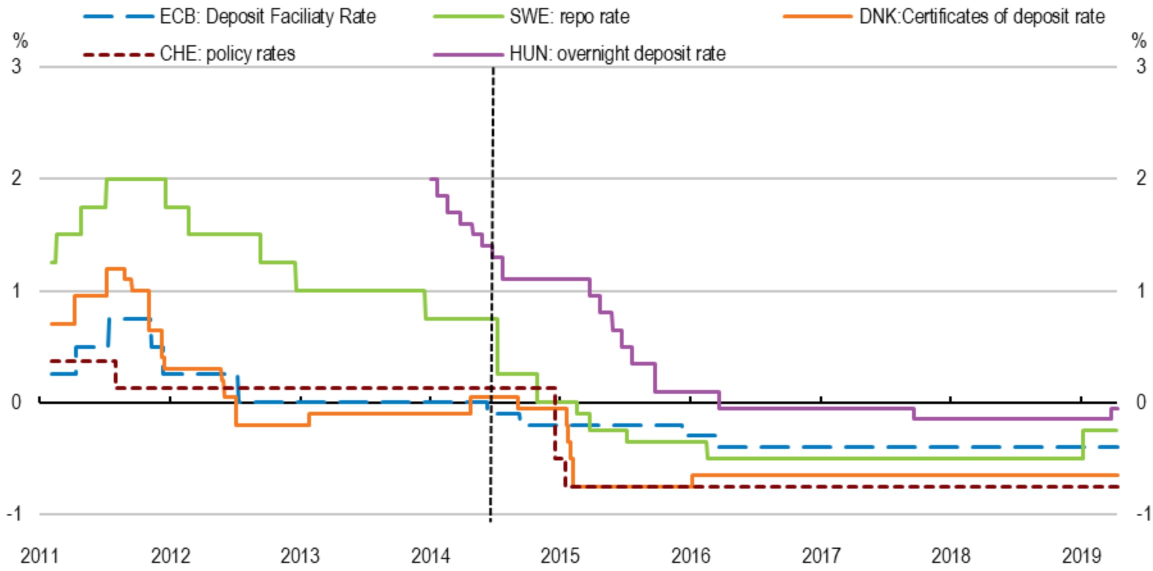
NEGATIVE INTEREST RATES IN THE EURO AREA: DOES IT HURT BANKS?

By Jan Stráský and Hyunjeong Hwang[1]

1.1. Introduction

The negative interest rate policy (NIRP) has been implemented in several European countries since 2012 (Figure 1) and has led to heated discussions about its effects on economic growth, inflation and the financial stability. Some economists emphasised that the central banks must use all the options to provide additional monetary accommodation in the situation where the “neutral” rate of interest is likely to be negative (Svensson, 2015; Cœuré, 2016). Others chose to focus on the unintended consequences of the extraordinary monetary policy stimulus, including negative interest rates, for banks’ profitability and the potential financial stability risks (White, 2016; Stiglitz, 2016).

Figure 1. Negative policy rates in Europe



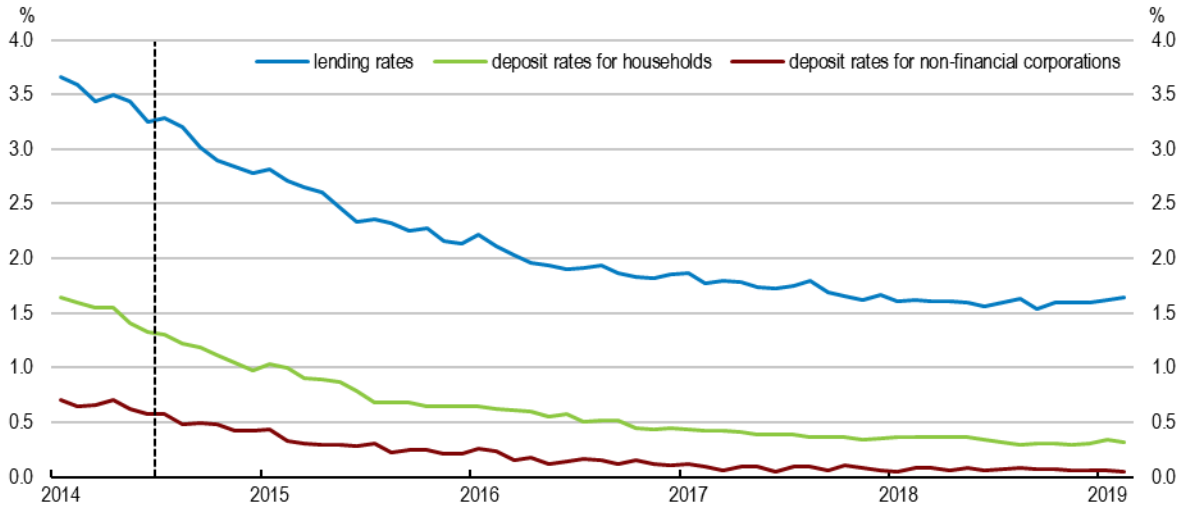
Note: The vertical line denotes the time when the euro area policy rate turned negative.
Source: European Central Bank, Sveriges Riksbank, Swiss National Bank, Danmarks Nationalbank, and Central Bank of Hungary.

[1] The authors are, respectively, Economist and Statistician in the Economics Department of the OECD. The authors would like to thank Caroline Roulet (DAF), Pierre Beynet, Aida Caldera Sánchez, Dennis Dlugosch, Selçuk Gul, Álvaro Pina, Mauro Pisu, Lukasz Rawdanowicz (all ECO) and the participants of the Economics Department Brownbag Lunch Seminar for valuable comments and suggestions at various stages of the preparation of this paper. The authors would also like to thank Jérôme Brezillon for the data on expectational variables as well as Alexandra Guerrero for excellent secretarial assistance.

The initial experience from the period of modestly negative policy rates suggested that the transmission to money market rates worked in the same way as at positive rates (Bech and Malkhozov, 2016; DNB, 2015). In the course of 2015, as some money market rates, such as repo rates, have dropped below the ECB deposit rate, the transmission mechanism got more complicated (Arrata et al., 2017). The transmission to the wider economy remains less evident still. Although the transmission takes place through the interest rate channel, the portfolio channel and the exchange rate channel, which are standard, negative interest rates could be associated with additional risks, especially if interest rates fall substantially below zero or stay in place for a longer period of time.

When policy interest rates are close to zero or negative, banks may protect their interest margins by not reducing lending rates in step with policy rates2 and by not reducing their deposit rates for corporate and individual depositors below zero. Such policies would allow banks, respectively, to keep lending low and prevent the diminishing of their deposit base by limiting depositors' incentive to switch to another bank. Indeed, the deposit rates in the euro area compressed by less than lending rates and remain well above zero (Figure 2).

Figure 2. Lending rates and deposit rates of the euro area banks



Note: Lending rates mean MFI interest rates on new euro-denominated loans to non-financial corporations for loans between EUR 250,000 and EUR 1 million over three months and up to one year initial rate fixation. Deposit rates mean MFI interest rates on new euro-dominated deposits from euro area residents with an agreed maturity of up to one year. The vertical line denotes the time when the euro area policy rate turned negative.
Source: European Central Bank.

Banks' decision not to pass the negative interest rates on to depositors directly affects their profitability. While the yield on bank assets gradually declines, the funding costs remains unchanged, thus compressing the net interest margin. Such deterioration in profitability, in particular over prolonged periods, reduces the banks' ability to create capital from retained earnings and hence its risk-bearing capacity and supply of credit (Cœuré, 2016). This approach could affect many companies, especially small and medium-sized enterprises, that are unable to borrow at anywhere close to the policy rate. Under these conditions, the

[2] In Switzerland during 2015, banks have raised the lending rate on mortgages, even as government and corporate bond yields fell in line with the money market rates (SNB, 2015).

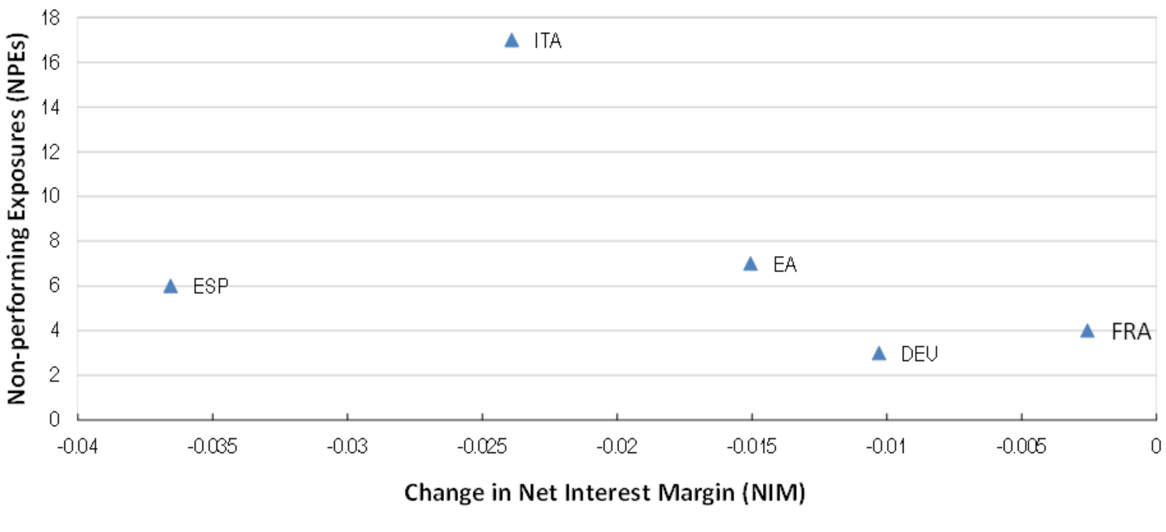
effect of lowering interest rates, even below zero, on bank lending may be diminishing (Borio and Gambacorta, 2017).

Overall, the interest rate margin dynamics is likely to differ from bank to bank, depending on their business model, the share of floating-rate lending in total lending, the source of bank's funding, the size of the bank and other characteristics. Floating-rate loans may be re-priced quickly, while banks with mostly fixed-rate lending may benefit from the dynamic effects associated with the decline in short-term interest rates, at least as long as borrowers keep their ability to repay. As for the bank size, it may be easier for large banks to raise funds in wholesale markets, partly because of the fixed nature of the costs, or hedge their exposures to interest rate risk (ECB, 2015a). On the other hand, larger institutions are often more complex, possibly resulting in lower efficiency and profitability (ECB, 2015b).

However, banks may also limit their lending for other reasons. For example, due to the existence in some countries of still considerable stock of non-performing loans that are difficult to work out or because of new banking regulations, such as Basel III liquidity rules, which may incentivise banks to hold a buffer stock of liquid assets rather than expand their retail and other lending activities (Roulet, 2018). On the one hand, low interest rates may reduce the default probability on outstanding loans, thus lowering loan loss provisions on new loans (Genay and Podjasek, 2014). On the other hand, the stock of existing non-performing loans have to be provisioned or written off, as prescribed by regulators, and higher levels of non-performing exposures could further limit the capacity of banks to maintain their interest margins (Figure 3).

Figure 3. Change in net interest margin and non-performing exposures

Non-annualised percentage point change and percent of total exposure, 2014-2016

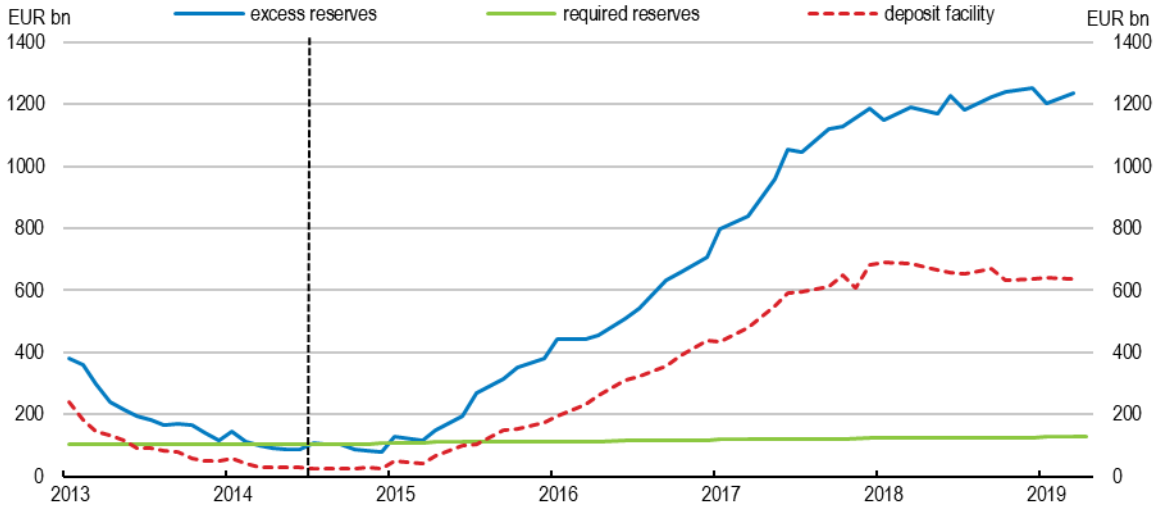


Note: NPEs as of March 2016; change in net interest margin between June 2014 and June 2016. Euro area values are calculated as a weighted average of values for the four countries.
Source: Bloomberg, EBA Report on the Dynamics and Drivers of Non-Performing Exposures in the EU Banking Sector (2016), financial statements of French banks, and OECD calculations.

Banks' profitability and lending could also suffer because of a large-scale asset purchase programme, which aims at compressing the term premium, thus limiting banks' profits from the maturity transformation. Monetary policy could eventually reach a "reversal rate", thus outweighing the benefits of lower interest rates (Brunnermaier and Koby, 2016). Finally, low bank lending may also be driven by weak demand for loans, partly due to an already high indebtedness in some countries. Although the credit growth in the euro area is recovering, albeit from very low levels, it remains weak in several countries.

The prudent lending behaviour of banks is reflected in the data on euro area banks' reserves (Figure 4). Even though the total amount of reserves in the banking system is decided by the central bank, in normal times the banks would try to minimise the amount of excess reserves by expanding their balance sheets, as it is more profitable for them to loan out funds than hold them in low-paying accounts with the central bank. However, since the deposit facility rate turned negative in June 2014, the total excess reserves of the euro area banks, including the amounts parked in the ECB deposit facility, have been steadily increasing until the beginning of 2018[3]. The increase in excess reserves was much stronger that the gradual expansion of required reserves that broadly reflect the (risk-weighted) size of banks' balance sheets. Although the direct cost of negative interest rates – i.e. the negative remunerations of excess reserves – is probably small compared to indirect effects on bank profitability, they may affect banks disproportionately, as the charges are generally larger in countries with substantial current account surpluses vis-à-vis other euro area countries (Jobst and Lin, 2016).

Figure 4. Excess reserves, required reserves and the deposit facility



Note: The vertical line denotes the time when the euro area policy rate turned negative.
Source: European Central Bank.

Against this background, the paper uses quarterly bank-level data for a group of directly supervised euro area banks to analyse the effects of the ECB's low interest rate policy on bank profitability. It contributes to the literature by modelling the negative interest rate period separately from the preceding period of low, but positive rates. In line with other studies in the literature, it finds limited evidence for an additional negative effect on bank profitability in the period of negative short-term interest rates. Similarly to other studies, the results also suggest that keeping rates low for an extended period of time may lead to slow deterioration in bank profitability.

[3] The amounts deposited in the ECB deposit facility reflect the excess reserves of the euro area banks vis-à-vis the Eurosystem, while the total excess reserves of the euro area banks include the excess reserves held with other central banks, outside the euro area, such as the Federal Reserve, the Bank of England or the Swiss National Bank.

The rest of the paper is organised as follows. The next section describes main stylised facts from our bank-level dataset. The next-to-last section discusses the estimation equation and the results from various econometric specifications. In conclusion, we summarise main findings and outline avenues for future research.

1.2. Stylised facts from the bank-level data

We base our analysis on a quarterly database containing data on a subset of the euro area banking groups directly supervised by the Single Supervisory Mechanism, as of 1 January 2016. The choice of the subset is based on the availability of consolidated basis data in Bloomberg. Since some bank groups only provide data on a semi-annual or annual basis, we have narrowed the list to 56 euro area banks from 15 countries, for which the quarterly data are available (see Appendix for the full sample of banks together with the reason for bank's significance). The data set is unbalanced, as the starting date of the data differs and some time series contain missing values, covering the period from 1999q1 to 2018q4. The bank-level data are all denominated in the euro and seasonally unadjusted. For the econometric estimation, the bank-level data from Bloomberg have been complemented by country-level data on the level of policy and short-term interest rates, the slope of the yield curve and other macroeconomic variables, such as GDP growth and expected real GDP growth and inflation from various sources (Table 1)[4].

Various measures of bank profitability indicate ongoing pressure on interest margins and a slow improvement in the rate of return on total assets (Figure 5). The dispersion of profitability outcomes, as measured by the distance between the first and the third quartile of the net interest income to assets distribution, has decreased at the beginning of the NIRP period and since then remained broadly constant. The best performing banks seem to be able to preserve their net interest margins, despite negative interest rates. However, the ability of the best performing banks to generate non-interest income has deteriorated, as reflected in the decreasing variability of non-interest income (Figure 5, panel B). Although the return on assets for the best performing banks is slowly recovering, the median remains below the pre-crisis level. It remains to be seen whether the average return on assets and the overall bank profitability is sufficient to cover the estimated cost of capital (Constâncio, 2016).

Moreover, for global banks with sizeable and often more profitable non-euro area operations, the calculated net interest margins may overstate the profitability of the euro area operations (Jobst and Lin, 2016) and/or misrepresent the actual currency composition of banks' liabilities and hence their refinancing costs (Borio et al., 2015). We have attempted to address this issue by a simple correction for the currency composition of the banks' assets and liabilities. We used the ECB data on domestic, euro area and the rest-of-the-world asset and liabilities positions of the euro area monetary financial institutions to calculate the shares of euro area and non-euro area operations. In addition, we assumed, rather crudely, that all the rest-of-the-world assets and liabilities are denominated and financed in US dollars. We then used the calculated asset weights to weigh the macroeconomic control variables, such as real GDP growth and inflation, while using the liabilities weights to adjust the financing variables, including the 3-month interest rate and the slope of the yield curve. Since this simple correction did not affect our estimation results, we continue to use the uncorrected data.

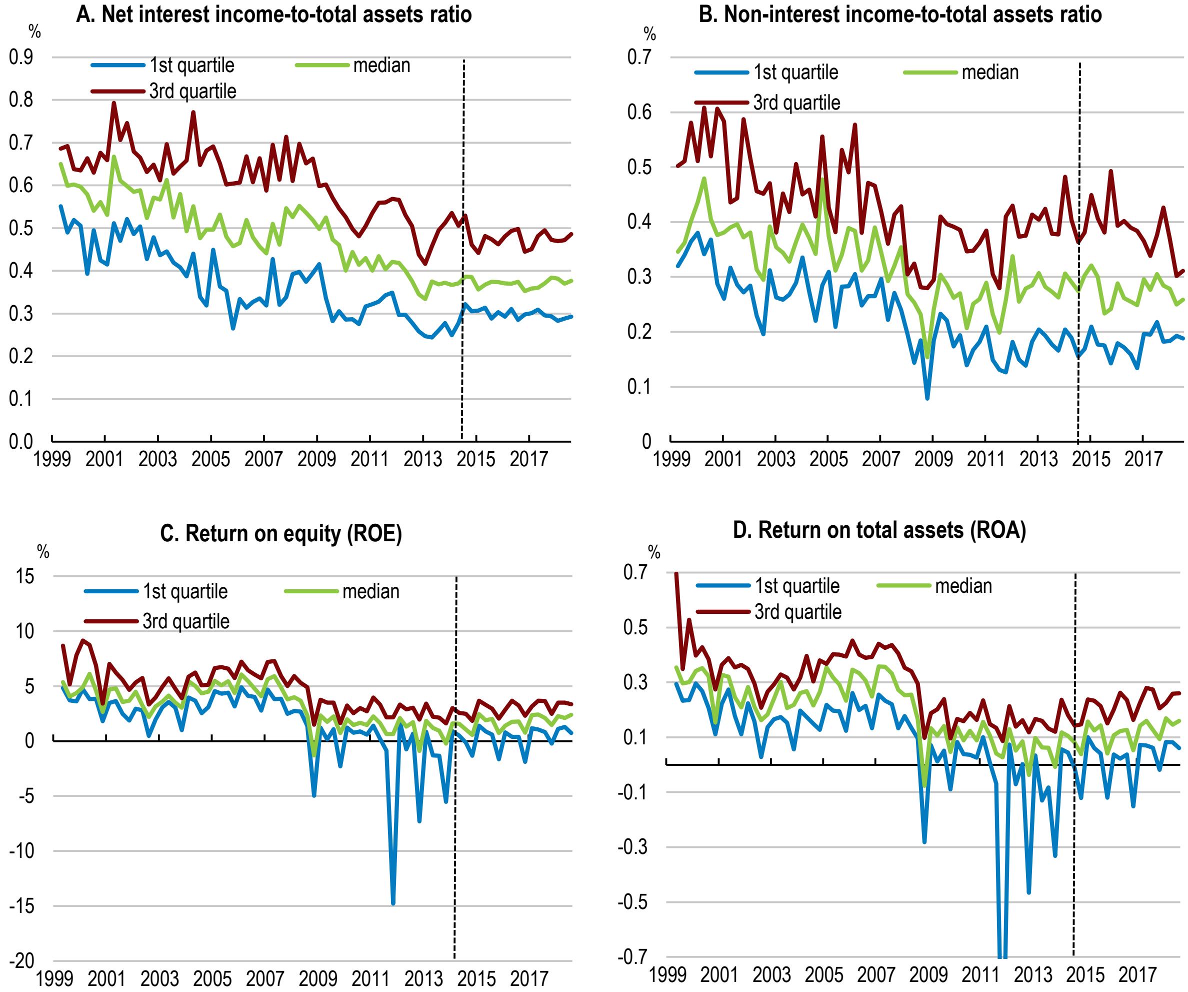
[4] The process of data extraction was automated using the Bloomberg add-in for MS Excel and several visual basic procedures; the data are then transformed into a Stata dataset for econometric analysis. The whole process is implemented in a way that can easily be replicated as new observations become available.

There is a clear increase in the ratio of customer deposits to liabilities of the euro area banks (Figure 6). Although it may be tempting, also in conjunction with the continuing fragmentation of the interbank market, to interpret this increase as a sign of a relatively stronger role for retail funding, customer deposits as defined by Bloomberg do not allow to clearly distinguish between the retail and wholesale funding. At least part of the increase may just represent an increased importance of deposits relative to banks' debt issuance.

Table 1. Data source and description of main variables

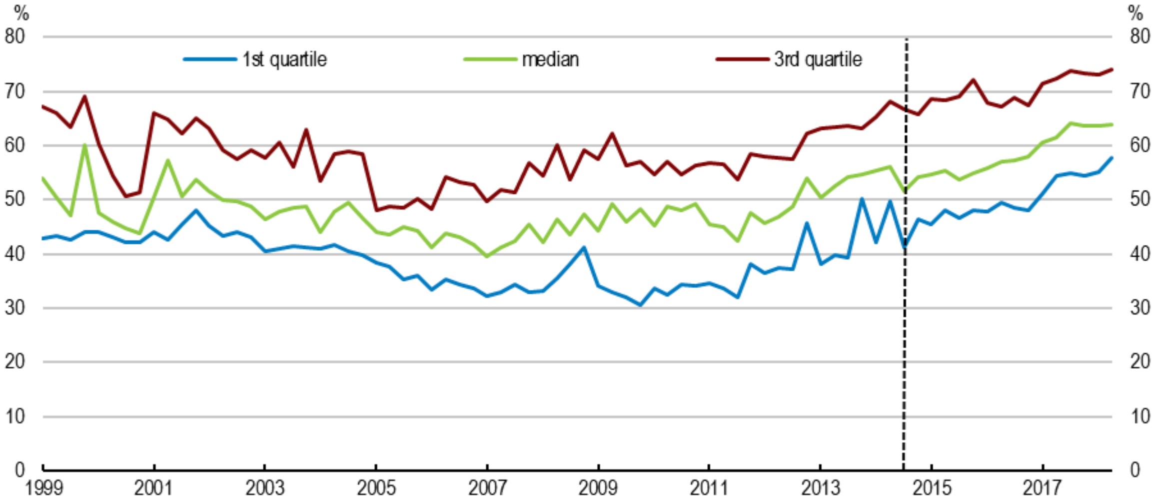
Variable	Definition	Data source
Profitability measures		
Net interest income (NII)	Net interest income to total assets	Bloomberg
Return on assets (ROA)	Pre-tax income to total assets	Bloomberg
Country-specific variables		
3 month interbank rate	3-month European interbank offered rate	OECD
The slope of the yield curve	Long term (in most cases 10 year) government bonds yield less the 3-month interbank rate	OECD
Real GDP growth	Real GDP growth rate, in percent	OECD
Expected real GDP growth	Expected growth of real GDP, Consensus Forecasts	Consensus Economics
Expected inflation	Expected inflation, Consensus Forecasts	Consensus Economics
Other bank-level variables		
Bank leverage	Equity to total assets ratio	Bloomberg
Total assets	Log of total assets	Bloomberg
Short-term borrowing	Short-term borrowing to total liabilities ratio. Short-term borrowings includes bank overdrafts, short-term debt and borrowing, repurchase agreements (repos) and reverse repos, short-term portion of long-term borrowings, etc.	Bloomberg
Provisions to total assets	Expenses for possible future loan losses divided by total assets	Bloomberg
Cost to income ratio	Operating costs divided by operating income	Bloomberg

Figure 5. Main components of bank profitability



Note: The vertical line denotes the time when the euro area policy rate turned negative.
Source: OECD calculations using Bloomberg data

Figure 6. Customer deposits to liabilities



Note: The vertical line denotes the time when the euro area policy rate turned negative.
Source: OECD calculations using Bloomberg data.

1.3. Econometric model of bank profitability

We first focus on the drivers of net interest income – i.e. the interest income less interest expense divided by total assets – that represents more than 60% of bank pre-tax income in the euro area (Coeuré, 2016)[5]. The link from the level of interest rates and the slope of the yield curve to net interest income is more direct that the effect on broader measures, such as to the return on assets or equity, which include other components, such as non-interest income.

Several single equation econometric models of the net interest margin have recently been estimated to shed more light on the dynamics of bank profitability in the environment of extraordinarily low interest rates. Claessens et al. (2016) collect annual balance sheet and income statement data for 2005-2013 for the total of 3418 banks from 47 countries and combine it with data on the 3-month interest rates and 10-year sovereign yields. They show that the negative effect on the net interest margins is stronger when the 3-month interest rates decline below 1.25%; a one percentage point decrease in the interest rate is associated with a 9 bps decrease in the net interest margin if rates are normal compared to a 17 bps decline in the low-rate environment. In addition, they find that the greater effect on the net interest margins in the low-rate environment is mainly driven by the greater pass-through of interest rates reductions to interest income than to interest expense. Borio et al. (2015) estimate the positive relationship between the level of interest rate and the slope of the yield curve, on the one hand, and various measures of bank profitability including the NIM, on the other. Using annual data for the period 1995-2012 on a panel of 109 large banks mainly from Europe, Japan and the United States, they confirm that the effect is non-linear. In other words, the decline in profitability is stronger when interest rates are lower (about 50 bps for 1 ppt change at the interest rate of 1% compared to 20 bps at a rate of 6%) and the yield curve less steep.

[5] Unlike in the U.S. and the U.K. where market-based financial intermediation plays a prominent role, in the euro area financial intermediation remains primarily bank-based (OECD, 2018). The concerns about bank profitability and their consequences on bank capitalisation are thus even more acute for the euro area banks.

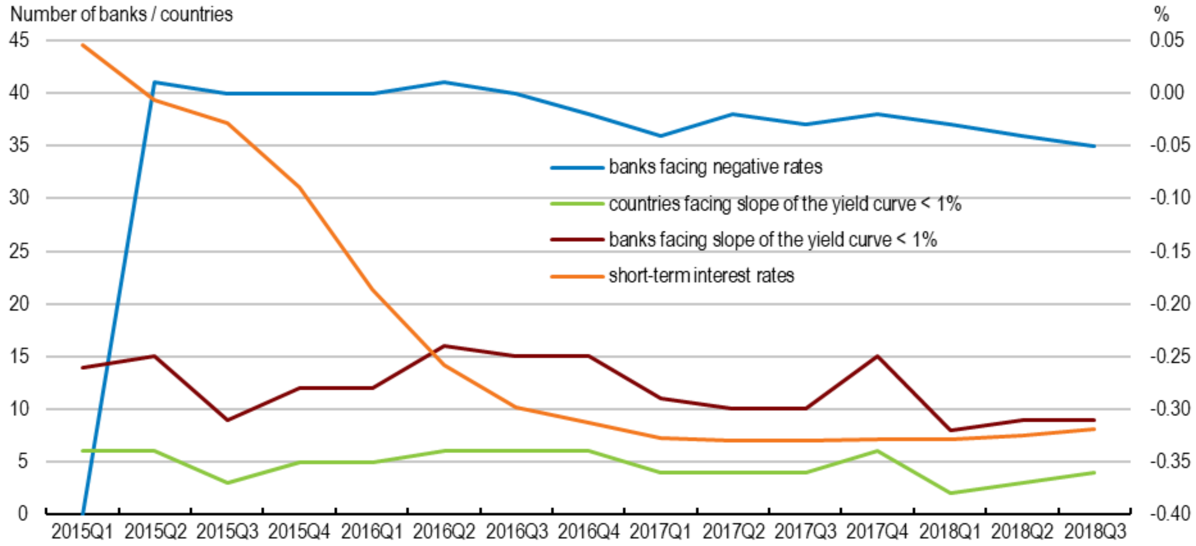
Country-specific studies points broadly in the same direction, but with more emphasis on wider positive effects of low interest rates for the real economy. Using quarterly data on 5583 US banks from 2003q3 to 2013q2, Genay and Podjasek (2014) find that interest rate changes have the expected negative effect on banks' net interest margin and affect smaller banks more strongly. However changes in general economic conditions, such as the unemployment rate and house prices, matter relatively more for bank profitability and the study concludes that the negative effects of low interest rates on bank profits are likely to be outweighed by the positive effects of low interest rates in boosting economic activity.

For the euro area, ECB (2015b) studies the determinants of profitability for 98 euro area banks using annual data from 1994 to 2014 and concludes that macroeconomic factors and not declining interest rates are the main drivers of bank profitability since the global financial crisis. On the contrary, ECB (2015a) using annual data from 1994 to 2014 for 72 euro area bank confirms the importance of interest rates as determinants of net interest margins and concludes that the prolonged period of low interest rates would seriously challenge banks' net interest income generation.

More recently, Altavilla et al. (2017) look at the effects of euro area monetary policy on bank profitability using quarterly data from 2000 to 2016. Using a rich set of country- and bank-specific control variables, they find that changes in the interest rate level and the slope of the yield curve are not associated with lower bank profits when controlling for the endogeneity of the policy measures to current and expected macroeconomic and financial conditions. Similarly to some previous research, monetary policy accommodation leads to improvements in macroeconomic outlook and increased bank lending that seems to outweigh the direct negative effects on bank profitability. The result of limited effect of the NIRP on bank profitability in the euro area, mainly due to the positive impact on lending volumes and induced capital gains, is confirmed by their follow up work (Altavilla et al., 2019). However, recent evidence from bank lending data collected by the ECB suggests that banks in the euro area that are more exposed to the NIRP tend to grant more loans (Demiralp et al., 2019). This result, which seems according to the authors driven by an explicit consideration of the role of excess liquidity, is consistent with higher risk taking by banks as a reaction to negative interest rates.

Our study contributes to the literature by analysing separately, for the first time to our knowledge, the period of negative 3-month interbank interest rates in the euro area that started in 2015q2. While the negative interest rates apply to all banks in our sample, and the variation in the number of banks facing negative interest rates basically reflects changes in the Bloomberg data availability, the number of banks facing the flattening yield curve remains limited to less than fifteen (Figure 7). Since our data set covers the period when negative interest rates were in place together with unconventional monetary policy measures, such as asset purchases leading to the flattening of the yield curve, the econometric analysis thus combines the effects of all monetary policy measures, not only those pertaining to the negative interest rate policy. This conflation is confirmed by the survey evidence reported in ECB (2016) that the NIRP has already hurt or is expected to hurt profitability (80% of participating banks), while banks also experienced and expected (despite improving capital gains) reduced net interest margins as a result of the ECB asset purchase programme (40% of banks).

Figure 7. Number of banks and countries facing negative interest rates and flattening yield curve



Note: Short-term interest rates are the 3-months nominal interest rates and the yield curve slope is defined as the difference between the yield on 10-years government bond in the country where the bank is headquartered and the 3-month nominal rate. Changing number of banks facing negative interest rates mainly reflects the changing availability of the bank-level profitability data in Bloomberg.
Source: OECD Economic Outlook 105 database and the European Central Bank.

Our estimation strategy is similar to Genay and Podjasek (2014), Borio et al. (2015) and Claessens et al. (2016). We regress the net interest margin defined as net interest income over total assets $NII_{i,c,t}$ (and, in alternative specifications, the interest income to assets, interest expenditure to assets, as well as other profitability measures discussed below) on the lagged dependent variable, the intercept, the 3-months (nominal) interbank interest rate, i_t, the slope of the yield curve defined as the difference between the yield on 10-years government bond in the country where the bank is headquartered and the 3-month rate, $y_{c,t}$, and bank, time and country fixed effects. In addition, we create two alternative dummy variables, D_t, that equals 1 if i_t<0 (and zero otherwise) and Low_t, which equals 1 if i_t<0.5% (and zero otherwise) and interact one or the other with both the 3-months interest rate and the slope of the yield curve. Finally, vector $X_{c,i,t}$ includes other relevant bank-specific and country specific variables, such as the equity to assets ratio (as a measure of solvency), the share of short-term borrowing to liabilities (as a measure of deposit vs. debt financing), the provisions to asset ratio (as a measure of risk taking) and growth rates of GDP, and inflation. In the version with net income interest to assets as the dependent variable and D_t as the interactions dummy, the estimation equation hence becomes

$$NII_{i,c,t} = \alpha_i + \alpha_1 NII_{i,c,t-1} + \alpha_2 i_t + \alpha_3 y_{c,t} + \alpha_4 D_t i_t + \alpha_5 D_t y_{c,t} + \sum_j \boldsymbol{\alpha_j X_{j,c,i,t}} + \varepsilon_{i,t} \quad (1)$$

The inclusion of the two interaction terms with the dummy variable allows us to assess the additional effect of the interest rate level and the slope of the yield curve when the level of interest rates becomes negative. Our estimation equation is theoretically motivated and can be derived from an optimising model of bank's behaviour (Freixas and Rochet, 1997; Borio et al., 2015). Assuming a symmetric equilibrium and a constant elasticity of loan and deposit volumes with respect to deposit and lending rates, it can be shown that the derivative of net interest income with respect to the nominal interest rate is positive, while the relationship between net interest income and the slope of the yield curve remains a priori uncertain. In addition, the relationship is possibly non-linear; the effect could be stronger at the lower levels of nominal interest rate.

Table 2 summarises the estimation results of several net interest income models including the interaction dummy variables that allow us to assess the additional effect of negative (or low) interest rates. All the estimation equations include an intercept, bank fixed effects and country fixed effects. Time dummies are included as indicated to control for other factors that vary over time. Using net interest income to assets as a dependent variable, the model provides limited evidence of the level and slope effects. The estimated coefficient on the interest rate level is positive and significant in some cases, and so is the estimate of the additional level effect when the 3-month rate turns negative (columns 1-3). An additional level effect can also be found in the regressions with interest rates below 0.5% (column 6). On the other hand, the slope effect estimates are often negative or insignificant.

Table 2. Models of the net interest income equation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
The dependent variable: $NII_{i,c,t}$	**Pooled OLS**	**Pooled OLS**	**FE**	**FE**	**Pooled OLS**	**Pooled OLS**	**FE**	**FE**
$NII_{i,c,t-1}$	0.273***	0.272***	0.130	0.133	0.273***	0.272***	0.126	0.126
	(0.021)	(0.021)	(0.083)	(0.096)	(0.021)	(0.021)	(0.083)	(0.094)
i_t	-0.003	0.016***	-0.003	0.016***	-0.003	0.017***	-0.002	0.015**
	(0.006)	(0.003)	(0.003)	(0.006)	(0.006)	(0.003)	(0.003)	(0.006)
$y_{c,t}$	-0.004	-0.004*	-0.008	-0.008**	-0.002	-0.000	-0.005	-0.005
	(0.003)	(0.002)	(0.005)	(0.004)	(0.003)	(0.002)	(0.005)	(0.003)
D_t*i_t	0.769***	0.218***	0.463**	0.041				
	(0.297)	(0.060)	(0.189)	(0.065)				
$D_t*y_{c,t}$	0.008**	0.005	-0.003	-0.007				
	(0.005)	(0.005)	(0.007)	(0.006)				
Low_t*i_t					0.181	0.0886***	0.251**	0.036
					(0.249)	(0.034)	(0.094)	(0.033)
$Low_t*y_{i,c,t}$					-0.003	-0.008***	-0.009	-0.011***
					(0.004)	(0.003)	(0.005)	(0.003)
Constant	0.345***	0.196***	0.530***	0.412***	0.338***	0.185***	0.524***	0.412***
	(0.089)	(0.025)	(0.054)	(0.053)	(0.089)	(0.025)	(0.054)	(0.049)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	No	Yes	No	Yes	No	Yes	No
Observations	2,289	2,289	2,289	2,289	2,289	2,289	2,289	2,289
Adjusted R^2	0.273	0.266	0.090	0.079	0.273	0.266	0.092	0.084
Number of groups			48	48			48	48

Note: The variables are defined as follows: NII is the aggregate net interest income over total assets, i_t is the 3-months interest rate, $y_{i,c,t}$ is the slope of the yield curve defined as the difference between the nominal yield on the 10-years government bond and the 3-months nominal interest rate, Low_t is a dummy variable equal to 1 when the 3-month nominal interest rate is below 0.5% and zero otherwise. All models include a constant and bank fixed effects; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. ***, **, and * denote significance at the 1%, 5%, and 10% level.

The estimation results become clearer when we disaggregate the net interest income and look separately at the drivers of the interest income to assets and the interest expense to assets. Let us start with models of the interest income to assets (Table 3). The equations with dummies for the negative interest rate periods show level effects and slope effects together that are appropriately signed as well as significant additional level effect for the period of negative interest rate (columns 2-4). The additional slope effect is significant, but negative, possibly indicating a boost that banks' interest income might have received from the flattening of the yield curve through the capital gains on longer-term government bonds. Similar picture can be seen in the regression using the dummies for low interest rate periods (columns 6-8). The additional level effect from negative interest rates tends to be considerably stronger than in the level effect associated with positive interest rates, in some cases more than one-for-one (column 1 and 3).

Table 3. Models of the interest income to assets

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable: $Int\_Inc\_A_{i,c,t}$	Pooled OLS	Pooled OLS	FE	FE	Pooled OLS	Pooled OLS	FE	FE
$Int\_Inc\_A_{i,c,t-1}$	0.535***	0.526***	0.300*	0.311*	0.536***	0.529***	0.302*	0.314*
	(0.0203)	(0.0199)	(0.156)	(0.158)	(0.0203)	(0.0199)	(0.156)	(0.157)
i_t	0.00981	0.0492***	0.0200***	0.0777***	0.0103	0.0525***	0.0200***	0.0803***
	(0.0118)	(0.00687)	(0.00501)	(0.0198)	(0.0119)	(0.00658)	(0.00528)	(0.0204)
$y_{c,t}$	0.00253	0.00178	0.0126**	0.00766*	0.00304	0.00619	0.0130**	0.0114**
	(0.00525)	(0.00434)	(0.00590)	(0.00447)	(0.00611)	(0.00450)	(0.00625)	(0.00478)
D_t*i_t	1.009*	0.299**	1.418***	0.232*				
	(0.576)	(0.128)	(0.436)	(0.117)				
$D_t*y_{c,t}$	-0.0153	-0.0153	-0.0208*	-0.0222**				
	(0.0117)	(0.0101)	(0.0121)	(0.0107)				
Low_t*i_t					0.184	0.207***	0.145*	0.177**
					(0.468)	(0.0712)	(0.0730)	(0.0659)
$Low_t*y_{c,t}$					-0.00652	-0.0152***	-0.00656	-0.0144**
					(0.00839)	(0.00580)	(0.00633)	(0.00613)
Constant	0.880***	0.733***	0.828***	0.513***	0.875***	0.712***	0.821***	0.474***
	(0.170)	(0.0577)	(0.196)	(0.137)	(0.171)	(0.0566)	(0.194)	(0.124)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	No	Yes	No	Yes	No	Yes	No
Observations	1,987	1,987	1,987	1,987	1,987	1,987	1,987	1,987
Adjusted R^2	0.499	0.482	0.316	0.285	0.499	0.482	0.315	0.283
Number of groups			47	47			47	47

Note: The variables are defined as follows: Int_inc_A is the interest income to assets, i_t is the 3-months interest rate, $y_{i,c,t}$ is the slope of the yield curve defined as the difference between the nominal yield on the 10-years government bond and the 3-months nominal interest rate, Low_t is a dummy variable equal to 1 when the 3-month nominal interest rate is below 0.5% and zero otherwise. All models include a constant and bank fixed effects; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. ***, **, and * denote significance at the 1%, 5%, and 10% level.

The estimated fixed effects models for the interest expenditure to assets suggest both the level and slope effect in the times of positive interest rates (Table 4). However, there is no evidence for an additional level effect when interest rates turn negative, while the estimated slope coefficients indicate improvements in profitability associated with the NIRP (columns 3 and 4). Using low interest rates periods instead of the negative interest rates, a fixed effect estimation finds a significant additional level effect (column 8).

Table 4. Models of the interest expense to assets

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable: $Int\_Exp\_A_{i,c,t}$	Pooled OLS	Pooled OLS	FE	FE	Pooled OLS	Pooled OLS	FE	FE
$Int\_Exp\_A_{i,c,t-1}$	0.833***	0.826***	0.606***	0.634***	0.835***	0.827***	0.608***	0.638***
	(0.0105)	(0.0104)	(0.115)	(0.102)	(0.0105)	(0.0103)	(0.114)	(0.0990)
i_t	0.00803*	0.0198***	0.0145***	0.0385***	0.00837*	0.0197***	0.0145***	0.0393***
	(0.00485)	(0.00302)	(0.00253)	(0.0117)	(0.00488)	(0.00290)	(0.00243)	(0.0122)
$y_{i,t}$	0.00269	0.00189	0.00831***	0.00545**	0.00320	0.00264	0.00835***	0.00620**
	(0.00219)	(0.00183)	(0.00290)	(0.00261)	(0.00255)	(0.00188)	(0.00229)	(0.00279)
D_t*i_t	0.0499	0.0131	0.348	0.0562				
	(0.247)	(0.0517)	(0.259)	(0.0549)				
D_t*$y_{i,c,t}$	-0.00772	-0.00587	-0.0104***	-0.00978***				
	(0.00477)	(0.00415)	(0.00270)	(0.00336)				
Low_t*i_t					0.0823	0.0267	0.0344	0.0658**
					(0.193)	(0.0292)	(0.0522)	(0.0304)
Low_t*$y_{i,c,t}$					-0.00398	-0.00372	-0.00292	-0.00402
					(0.00347)	(0.00242)	(0.00350)	(0.00306)
Constant	0.213***	0.227***	0.163	0.0988**	0.209***	0.225***	0.159	0.0887**
	(0.0754)	(0.0243)	(0.0996)	(0.0485)	(0.0756)	(0.0238)	(0.100)	(0.0398)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	No	Yes	No	Yes	No	Yes	No
Observations	1,814	1,814	1,814	1,814	1,814	1,814	1,814	1,814
Adjusted R^2	0.877	0.871	0.738	0.717	0.877	0.870	0.738	0.716
Number of groups			45	45			45	45

Note: The variables are defined as follows: Int_exp_A is the interest expense to assets, i_t is the 3-months interest rate, $y_{i,c,t}$ is the slope of the yield curve, defined as the difference between the nominal yield on the 10-years government bond and the 3-months nominal interest rate, Low_t is a dummy variable equal to 1 when the 3-month nominal interest rate is below 0.5% and zero otherwise. All models include a constant and bank fixed effect; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. ***, **, and * denote significance at the 1%, 5%, and 10% level.

Our model is strictly speaking a dynamic panel data model, due to the presence of both the lagged dependent variable and the endogenous explanatory variables. While we acknowledge the Nickell bias (Nickell, 1981) in principle, we note that our model is not the classical case of a “small T, large N” panel with few time periods and many individuals, for which the corrective approaches in dynamic panel data were primarily developed (Arellano and Bond, 1991; Arellano and Bover, 1995). Our dataset contains 45 to 48 groups, depending on the precise choice of the dependent variable, and the average number of observations per group is between 40 and 42; hence, the minimum number of groups and time periods is N=45 and T=40. Since the dynamic panel bias becomes insignificant when T is large, we use as our baseline model the more straightforward fixed-effects estimator, as recommended by Roodman (2009).

As robustness check, we also estimate the dynamic panel data models using the Arellano and Bond estimator (the difference GMM estimator) and the Arellano and Bover estimator (the system GMM estimator). Depending on the model specification, we include one or two lags of the dependent variable and use lags 2 to 4 in the case of one lag (or lags 3 to 4 in the case of two lags) as instruments (Tables A.3 and Table A.4 in the Appendix). All the estimated GMM models include time and country fixed effects, as indicated; in the case of the system GMM estimator, the time fixed effects are only used as instruments in the levels equation. Reported coefficients are based on the one-step estimator with robust standard errors (the Arellano-Bond robust variance-covariance matrix estimator). The Arellano-Bond test for zero autocorrelation in first-differenced errors is conducted to check the presence of residual autocorrelation. The GMM result are less robust than the pooled OLS and fixed effect models described above: despite some evidence for the level effect in normal times, the coefficients representing the slope effect under both positive and negative interest rates are not significant at the conventional levels.

We also complemented the basic model by further analysis distinguishing between small, medium and large banks in terms of total assets. However, the effect of declining interest rates and flattening yield curve on bank profitability does not appear to be varying with the size of the balance sheet and there is little evidence for additional effect associated with negative interest rates (Table A.5 in the Appendix).

We consider two further extensions of the baseline model, in order to check the robustness of our findings. First, we look at the determinants of the rate of return on banks' assets, a broader measure of bank profitability; second, we look at a broader definition of low interest rates and the long-term effects of low interest rates on bank profitability. We find some evidence for the importance of expected macroeconomic variables, such as expected inflation, as well as bank specific variables, including bank size (measured by total assets) and cost-to-income ratio (Table 5). However, there is little evidence that the level of interest rate and slope of the yield curve would have any systematic effect on banks' returns on asset. Looking at the components of bank profitability in more detail, the same seems to be the case for net interest income. On the contrary, non-interest income and the ratio of provisions to total assets seem to be sensitive to the level of interest rate and the slope of the yield curve (columns 5 and 6), while for provisions the slope effect seems to be stronger in the period of negative interest rates (column 6). Our results may partly reflect the positive effect on non-interest income from unconventional monetary policy, such as capital gains from buoyant financial market valuations (Altavilla et al., 2017).

In addition, we consider defining the period of low interest rates in a less restrictive manner, as the time when short-term interest rate decreases below 0.5%. Such an alternative measure increases the number of observations in our period of interest and allows us to consider the existence of a zero rate threshold, as compared to a low interest rate effect. In addition, following the approach in Claessens et al. (2017) and Altavilla et al. (2017), we include in our model a variable that counts the number of consecutive periods, in which the interest rate has stayed below the 0.5% threshold. This variable could capture some adverse effects on bank profitability from interest rates remaining low for a prolonged period of time (Table 6). The model works best for the return on assets measure of profitability (columns 1 and 2). There is a level effect from the interest rate and an additional effect from the interest rate below the 0.5% threshold. For other profitability measures there are no discernible effects on bank profits.

Table 5. The return on assets and profitability components

Dependent Variable	(1) $ROA_{i,t}$	(2) $ROA_{i,t}$	(3) $ROA_{i,t}$	(4) $NII_{i,t}$	(5) $NNI_{i,t}$	(6) $Prov_{i,t}/A_{i,t}$
$LDV_{i,t-1}$	0.0508*	0.0245	0.0261	0.0581	0.00627	-0.00399
	(0.0277)	(0.0199)	(0.0239)	(0.0672)	(0.0227)	(0.0238)
i_t	-0.0232	-0.0346**	0.000815	0.0133*	-0.0288***	0.0443***
	(0.0174)	(0.0152)	(0.0209)	(0.00701)	(0.0102)	(0.0148)
$y_{c,t}$	0.0248	0.00133	0.00770	-0.00482	-0.0185***	0.0313***
	(0.0155)	(0.0114)	(0.0131)	(0.00545)	(0.00691)	(0.0103)
$D_t{*}i_t$	0.269	0.270	0.164	0.0390	0.185	-0.0545
	(0.269)	(0.282)	(0.291)	(0.0721)	(0.141)	(0.161)
$D_t{*}y_{c,t}$	0.0272	0.0357**	0.0301*	-0.00926	0.00418	0.0291***
	(0.0187)	(0.0166)	(0.0165)	(0.00702)	(0.0119)	(0.00964)
$ln(A_{i,t})$		0.0746*	0.0803	-0.0757**	0.0573**	0.0252
		(0.0396)	(0.0581)	(0.0296)	(0.0277)	(0.0380)
$E_{i,t}/A_{i,t}$		-0.0228*	-0.0267*	0.0150***	-0.00464	-0.0214*
		(0.0135)	(0.0157)	(0.00331)	(0.00608)	(0.0120)
$SB_{i,t}/L_{i,t}$		0.00378**	0.00463**	-0.000369	0.000912	0.00302**
		(0.00162)	(0.00200)	(0.000496)	(0.000608)	(0.00143)
$CIR_{i,t}$		-0.00266**	-0.00266**	-1.42e-05	-0.00157**	-0.00107
		(0.00121)	(0.00122)	(5.08e-05)	(0.000647)	(0.000706)
$RGDP_{,c,t}$		-0.00660	0.00539	-0.00122	-0.00498	0.0106
		(0.00771)	(0.0103)	(0.00306)	(0.00544)	(0.00854)
$E\_RGDP_{c,t+1}$			-0.0533	-0.0126	0.0450*	-0.104***
			(0.0413)	(0.0215)	(0.0228)	(0.0326)
$E\_PIE_{c,t+1}$			-0.210***	0.0390	0.0254	-0.257***
			(0.0778)	(0.0342)	(0.0481)	(0.0569)
Country dummies	No	No	Yes	Yes	Yes	Yes
Time dummies	No	No	No	No	No	No
Observations	2,163	2,129	1,816	1,926	2,053	1,934
Number of groups	48	48	47	47	51	51
Adjusted R^2	0.0330	0.190	0.189	0.0675	0.127	0.159

Note: The variables are defined as follows: $ROA_{i,t}$ is the return on assets defined as the sum of the net interest income, net non-interest income and provisions as a fraction of total assets, $NII_{i,t}$ is net interest income, $NNI_{i,t}$ is the net non-interest income defined as non-interest income less non-interest expense as a fraction of total assets. $Prov_{i,t}/A_{i,t}$ is the provision to total assets, where $A_{i,t}$ are total assets and $Prov_{i,t}$ are provisions against loan losses, $LDV_{i,t-1}$ is the lagged dependent variable, i_t is the 3-months interest rate, $y_{i,t}$ is the slope of the yield curve, $E_{i,t}$ is total equity, $SB_{i,t}$ is short-term borrowing, $L_{i,t}$ are liabilities (i.e. assets less equity), $CIR_{i,t}$ is the cost-to-income ratio, $RGDP_{i,t}$ is real GDP growth and $E\_RGDP_{i,c,t+1}$ and $E\_PIE_{i,c,t+1}$ are the expected real GDP growth and inflation respectively. All models include a constant and bank fixed effect; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. The reported adjusted R^2 refers to corr(x_(i,t) β̂,y_(i,t)). ***, **, and * denote significance at the 1%, 5%, and 10% level.

Table 6. Low rates and low-for-long

Dependent variable	(1) $ROA_{i,t}$	(2) $ROA_{i,t}$	(3) $NII_{i,t}$	(4) $NII_{i,t}$	(5) $NNI_{i,t}$	(6) $NNI_{i,t}$
$LDV_{i,t-1}$	0.0208	0.0208	0.0717	0.0657	0.0159	0.0154
	(0.0233)	(0.0233)	(0.0610)	(0.0600)	(0.0219)	(0.0219)
i_t	0.0799***	0.0799***	-0.00220	-0.00147	0.00190	-0.00216
	(0.0291)	(0.0291)	(0.00680)	(0.00585)	(0.0130)	(0.0117)
$y_{c,t}$	0.0112	0.0112	-0.00561	-0.00556	-0.0123*	-0.0128*
	(0.0143)	(0.0143)	(0.00512)	(0.00510)	(0.00663)	(0.00653)
Low_t (<0.5)	0.272**		0.0480		0.0398	
	(0.114)		(0.0406)		(0.0568)	
Low_cum_t		0.272**		-0.0100		0.0375
		(0.114)		(0.0215)		(0.0422)
$ln(A_{i,t})$	0.0428	0.0428	-0.0458	-0.0529	0.0696	0.0759
	(0.119)	(0.119)	(0.0306)	(0.0320)	(0.0451)	(0.0456)
$E_{i,t}/A_{i,t}$	-0.0249	-0.0249	0.0153***	0.0150***	-0.00223	-0.00177
	(0.0167)	(0.0167)	(0.00349)	(0.00377)	(0.00725)	(0.00744)
$SB_{i,t}/L_{i,t}$	0.00540**	0.00540**	-0.000506	-0.000449	0.000344	0.000229
	(0.00222)	(0.00222)	(0.000597)	(0.000614)	(0.000663)	(0.000728)
$CIR_{i,t}$	-0.00272**	-0.00272**	-3.42e-05	-3.11e-05	-0.00157**	-0.00157**
	(0.00120)	(0.00120)	(4.89e-05)	(4.87e-05)	(0.000633)	(0.000632)
$RGDP_{c,t}$	0.0114	0.0114	-0.00326	-0.00341	0.00594	0.00519
	(0.0130)	(0.0130)	(0.00280)	(0.00290)	(0.00921)	(0.00889)
$E\_GDPV_{c,t+1}$	0.00453	0.135*		-0.0143	0.0653**	0.0850**
	(0.0564)	(0.0754)		(0.0253)	(0.0299)	(0.0356)
$E\_PIE_{,c,t+1}$	-0.264	2.462*		-0.0823	0.0134	0.401
	(0.232)	(1.288)		(0.223)	(0.0661)	(0.452)
$E(t\text{-}1)\_GDPV_{c,t}$			-0.0152*			
			(0.00853)			
$E(t\text{-}1)\_PIE_{c,t}$			0.0845**			
			(0.0352)			
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,816	1,816	2,034	1,926	2,053	2,053
Number of groups	47	47	48	47	51	51
Adjusted R2	0.196	0.196	0.0802	0.0742	0.147	0.147

Note: The variables are defined as follows: $ROA_{i,t}$ is the return on assets defined as the sum of the net interest income, net non-interest income and provisions as a fraction of total assets, $NII_{i,t}$ is the net interest income, $NNI_{i,t}$ is the net non-interest income defined as non-interest income less non-interest expense as a fraction of total assets, $LDV_{i,t-1}$ is the lagged dependent variable, i_t is the 3-months interest rate, $y_{c,t}$ is the slope of the yield curve, Low_t is a dummy variable equal to 1 when the 3-month nominal interest rate is below 0.5% and zero otherwise and Low_cum_t is a count variable that equals to a number of consecutive quarters with low interest rates. Furthermmore, $A_{i,t}$ are total assets, $E_{i,t}$ is total equity, $SB_{i,t}$ is short-term borrowing, $L_{i,t}$ are liabilities (i.e. assets less equity), $CIR_{i,t}$ is the cost-to-income ratio, $RGDP_{c,t}$ is real GDP growth and $E\_RGDP_{c,t+1}$ and $E\_PIE_{c,t+1}$ are the expected real GDP growth and inflation, respectively. All models include a constant and bank fixed effect; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. The reported adjusted R2 refers to corr(x_(i,t) β ̂,y_(i,t)). ***, **, and * denote significance at the 1%, 5%, and 10% level.

1.4. Conclusions

Despite the apparent resilience of banks' net interest margins (Figure 5), our pooled OLS and fixed effect models confirm the level and slope effects of interest rate on banks' profitability and provide mixed evidence on an additional negative effect in the recent period when euro area short-term interest rates became negative. These effects are unrelated to the size of bank's balance sheet and tend to weaken when additional macroeconomic variables are included in the regression. Moreover, the decreasing variability in non-interest income (Figure 5, panel B) suggests that the best-performing banks are facing difficulties in replacing the declining interest income by non-interest income, as their results become more like those of the weaker banks. Although we find mixed evidence of negative effects on bank profitability from the negative interest rate policy, our results are, in our view, consistent with the need for continuing improvements of banks' profitability. This seems to be a prudent policy in any case, and even more so in the view of possible negative effects on bank profitability from keeping rates low for an extended period of time.

The banks can preserve their profitability either by cost cutting, including lowering the excess capacity in the banking sector, by mobilising the sources of non-interest income and by preventing the pass-through of the policy rates into the lending rates. Business model based on increased non-interest income will likely only work for individual banks and policies aimed at higher non-interest income generation could also reduce the effectiveness of the monetary policy transmission mechanism. Furthermore, adequate profitability of banks is relevant for the smooth provision of credit to the economy, the ability to reduce non-performing loans and loan loss provisioning and, through the ability to attract capital from market investors, for financial stability (Admati and Helwig, 2014).

1.5. REFERENCES

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APPENDIX: DATA SOURCES, DESCRIPTIVE STATISTICS AND FURTHER RESULTS

Table A.1. The list of banking groups included in the estimation

Bank group name	Country of establishment	The reason for significance
Erste Group Bank AG	Austria	EUR 150-300 bn
Dexia NV	Belgium	EUR 150-300 bn
KBC Group N.V.	Belgium	EUR 150-300 bn
AS SEB Pank	Estonia	Total assets above 20 % of GDP
Swedbank AB	Estonia	Total assets above 20 % of GDP
OP Osuuskunta	Finland	EUR 100-125 bn
BNP Paribas	France	above EUR 1,000 bn
Groupe BPCE (PE General Partner)	France	above EUR 1,000 bn
Crédit Agricole S.A.	France	above EUR 1,000 bn
Société générale S.A.	France	above EUR 1,000 bn
Aareal Bank AG	Germany	EUR 50-75 bn
Bayerische Landesbank	Germany	EUR 150-300 bn
COMMERZBANK Aktiengesellschaft	Germany	EUR 500-1,000 bn
Deutsche Bank AG	Germany	above EUR 1,000 bn
HSH Nordbank AG	Germany	EUR 100-125 bn
Deutsche Pfandbriefbank AG	Germany	EUR 50-75 bn
Landesbank Hessen-Thüringen Girozentrale	Germany	EUR 150-300 bn
Norddeutsche Landesbank -Girozentrale	Germany	EUR 150-300 bn
Alpha Bank, S.A.	Greece	EUR 50-75 bn
Eurobank Ergasias, S.A.	Greece	EUR 50-75 bn
National Bank of Greece, S.A.	Greece	EUR 100-125 bn
Piraeus Bank, S.A.	Greece	EUR 75-100 bn
Banca Carige S.p.A. – Cassa di Risparmio di Genova	Italy	EUR 30-50 bn
BANCA MONTE DEI PASCHI DI SIENA S.P.A.	Italy	EUR 150-300 bn
Banco Popolare – Società Cooperativa	Italy	EUR 125-150 bn
Banca popolare dell'Emilia Romagna Società Cooperativa	Italy	EUR 50-75 bn
BANCA POPOLARE DI MILANO – Società Cooperativa a responsabilità Limitata	Italy	EUR 30-50 bn
Banca Popolare di Sondrio, Società Cooperativa	Italy	EUR 30-50 bn
Credito Emiliano S.p.A.	Italy	EUR 30-50 bn
Intesa Sanpaolo S.p.A.	Italy	EUR 500-1,000 bn
Mediobanca – Banca di Credito Finanziario S.p.A.	Italy	EUR 50-75 bn
UniCredit S.p.A.	Italy	EUR 500-1,000 bn
Unione di Banche Italiane Società per Azioni	Italy	EUR 100-125 bn
ABLV Bank, AS	Latvia	Among the three largest credit institutions in the Member State
AS SEB Banka	Latvia	Among the three largest credit institutions in the Member State
Swedbank AS	Latvia	Total assets above 20 % of GDP
AB DNB bankas	Lithuania	Among the three largest credit institutions in the Member State
Banco BPI, SA	Portugal	EUR 30-50 bn
Banco Comercial Português, SA	Portugal	EUR 75-100 bn
Caixa Geral de Depósitos, SA	Portugal	EUR 100-125 bn

Slovenská sporiteľňa, a.s.	Slovakia	Among the three largest credit institutions in the Member State
Tatra banka, a.s	Slovakia	Among the three largest credit institutions in the Member State
Všeobecná úverová banka, a.s.	Slovakia	Among the three largest credit institutions in the Member State
Nova Ljubljanska Banka d.d. Ljubljana	Slovenia	Total assets above 20 % of GDP
Nova Kreditna Banka Maribor d.d.	Slovenia	Among the three largest credit institutions in the Member State
Banco Bilbao Vizcaya Argentaria, S.A.	Spain	EUR 500-1,000 bn
Banco de Sabadell, S.A.	Spain	EUR 150-300 bn
BFA Tenedora De Acciones S.A.U.	Spain	EUR 150-300 bn
Banco Popular Español, S.A.	Spain	EUR 150-300 bn
Banco Santander, S.A.	Spain	above EUR 1,000 bn
Bankinter, S.A.	Spain	EUR 50-75 bn
Banco de Crédito Social Cooperativo, S.A.	Spain	EUR 30-50 bn
Kutxabank, S.A.	Spain	EUR 50-75 bn
Liberbank, S.A.	Spain	EUR 30-50 bn
ABN AMRO Group N.V.	The Netherlands	EUR 300-500 bn
ING Groep N.V.	The Netherlands	EUR 500-1,000 bn

Source: European Central Bank.

Table A.2. Summary statistics of main variables used in the un-weighted regression model

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Net interest income to total assets (NII, %)	2,289	0.463287	0.259277	-0.39924	4.830478
Return on assets (ROA, %)	2,163	-0.01212	0.54718	-6.8918	10.31596
3-month interbank rate (%)	2,289	1.503727	1.837113	-0.32997	15.69667
Slope of the yield curve (%)	2,289	2.504739	2.856346	-4.03333	24.70397
Short-term borrowing to liabilities (%)	2,129	17.16278	10.94862	0	97.14697
Log of total assets	2,129	11.54848	1.391353	6.836043	14.65074
Equity to total assets (%)	2,129	6.635872	2.749198	-4.89898	22.41258
Cost-to-income ratio (%)	2,129	62.89779	79.3536	-1737.85	2010.54
Real GDP growth (%)	2,129	0.886365	2.962758	-16.7122	12.02773
Expected real GDP growth	2,053	1.4052	0.543452	-0.21351	2.266686
Expected inflation	2,053	1.567661	0.32388	0.839966	2.463961
Interest income to asset	1,987	0.963306	0.580312	-0.39885	6.919539
Interest expense to asset	1,814	0.534808	0.483177	0	4.295492

Source: Bloomberg and OECD calculations.

Table A.3. Difference GMM models

Dependent variable	(1) $NII_{i,t}$	(2) $NII_{i,t}$	(3) $Int\_inc\_A_{i,t}$	(4) $Int\_inc\_A_{i,t}$	(5) $Int\_exp\_A_{i,t}$	(6) $Int\_exp\_A_{i,t}$
$LDV_{i,t-1}$	0.2081	0.6561***	0.1537	0.2560	1.0646***	1.1542***
	(0.1882)	(0.1485)	(0.1857)	(0.3360)	(0.0776)	(0.1058)
$LDV_{i,t-2}$	0.1503	0.1208	0.2627***	0.2399***	-0.1758**	-0.1949**
	(0.0769)	(0.0713)	(0.0816)	(0.0835)	(0.0702)	(0.0956)
it	0.0144**	0.0068	0.0767***	0.0610	0.0167***	0.0082
	(0.0070)	(0.0048)	(0.0280)	(0.0344)	(0.0057)	(0.0041)
$y_{i,c,t}$	-0.0071	-0.0014	0.0043	0.0084	0.0022	0.0020
	(0.0046)	(0.0016)	(0.0082)	(0.0079)	(0.0019)	(0.0011)
$D*i_t$	-0.0057	-0.0020	0.0311	0.0847	0.0070	-0.0176
	(0.0386)	(0.0324)	(0.0878)	(0.1271)	(0.0170)	(0.0253)
$D*y_{i,c,t}$	-0.0096	-0.0005	-0.0275	-0.0165	-0.0005	-0.0017
	(0.0085)	(0.0022)	(0.0188)	(0.0135)	(0.0024)	(0.0013)
Country Ds	No	Yes	No	Yes	No	Yes
Time Ds	Yes	No	Yes	No	Yes	No
Observations	2,172	2,172	1,867	1,867	1,704	1,704
Number of groups	43	43	42	42	40	40
Number of instruments	86	20	86	20	86	20
AR(1) test **AR(2) test** **AR(3) test**	0.046 0.552 0.493	0.175 0.318 0.362	0.028 0.145 0.269	0.143 0.668 0.169	0.001 0.000 0.291	0.003 0.001 0.283
Adjusted R^2						

Note: The variables are defined as follows: $NII_{i,c,t}$ is the aggregate net interest income to total assets, $Int\_inc\_A_{i,t}$ and $Int\_exp\_A_{i,t}$ are interest income and interest expense to assets, respectively, $LDV_{i,t-1}$ and $LDV_{i,t-2}$ are the once- and twice-lagged dependent variables, respectively, i_t is the 3-months interest rate, and $y_{c,t}$ is the slope of the yield curve. All models include a constant and bank fixed effect; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. The reported adjusted R2 refers to corr(x_(i,t) β ̂,y_(i,t)). ***, **, and * denote significance at the 1%, 5%, and 10% level.

Table A.4. System GMM models

Dependent variable	(1) $NII_{i,t}$	(2) $NII_{i,t}$	(3) $Int\_inc\_A_{i,t}$	(4) $Int\_inc\_A_{i,t}$	(5) $Int\_exp\_A_{i,t}$	(6) $Int\_exp\_A_{i,t}$
$LDV_{i,t-1}$	0.4736***	0.8629***	0.168	0.440*	1.052***	1.205***
	(0.1287)	(0.0757)	(0.159)	(0.244)	(0.0894)	(0.115)
$LDV_{i,t-2}$	0.1618**	0.0994	0.268***	0.0913	-0.166**	-0.226**
	(0.0075)	(0.0668)	(0.078)	(0.0881)	(0.0705)	(0.0974)
i_t	0.0145*	0.0002	0.0852**	0.0558*	0.0173***	0.00265
	(0.0075)	(0.0025)	(0.0343)	(0.0289)	(0.00497)	(0.00440)
$y_{c,t}$	0.0011	-0.0000	0.0095	0.00410	0.000675	-0.00375
	(0.0015)	(0.0010)	(0.0091)	(0.0112)	(0.00209)	(0.00266)
D^*i_t	0.0615*	0.0415**	0.0885	0.269	-0.00752	0.0270
	(0.0354)	(0.0172)	(0.119)	(0.176)	(0.0304)	(0.0346)
$D^*y_{c,t}$	0.0067*	0.0039***	-0.012	-0.00546	-0.0035**	0.0015
	(0.0034)	(0.0013)	(0.010)	(0.0111)	(0.0017)	(0.0016)1
Constant	0.1430**	0.0154	0.389***	0.360*	0.0288	0.0011
	(0.0661)	(0.0163)	(0.141)	(0.190)	(0.0201)	(0.017)
Country Ds	No	Yes	No	Yes	No	Yes
Time Ds	Yes	No	Yes	No	Yes	No
Observations	2,216	2,216	1,910	1,910	1,745	1,745
Number of groups	44	44	43	43	41	41
Number of instruments	90	29	90	16	90	16
AR(1) test **AR(2) test** **AR(3) test**	0.092 0.259 0.402	0.153 0.214 0.327	0.023 0.138 0.264	0.031 0.093 0.129	0.001 0.000 0.286	0.001 0.001 0.306
Adjusted R^2						

Note: The variables are defined as follows: $NII_{i,c,t}$ is the aggregate net interest income to total assets, $Int\_inc\_A_{i,t}$ and $Int\_exp\_A_{i,t}$ are interest income and interest expense to assets, respectively, $LDV_{i,t-1}$ and $LDV_{i,t-2}$ are the once- and twice-lagged dependent variables, respectively, i_t is the 3-months interest rate, and $y_{c,t}$ is the slope of the yield curve. All models include a constant and bank fixed effect; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. The reported adjusted R2 refers to corr(x_(i,t) β ̂,y_(i,t)). ***, **, and * denote significance at the 1%, 5%, and 10% level.

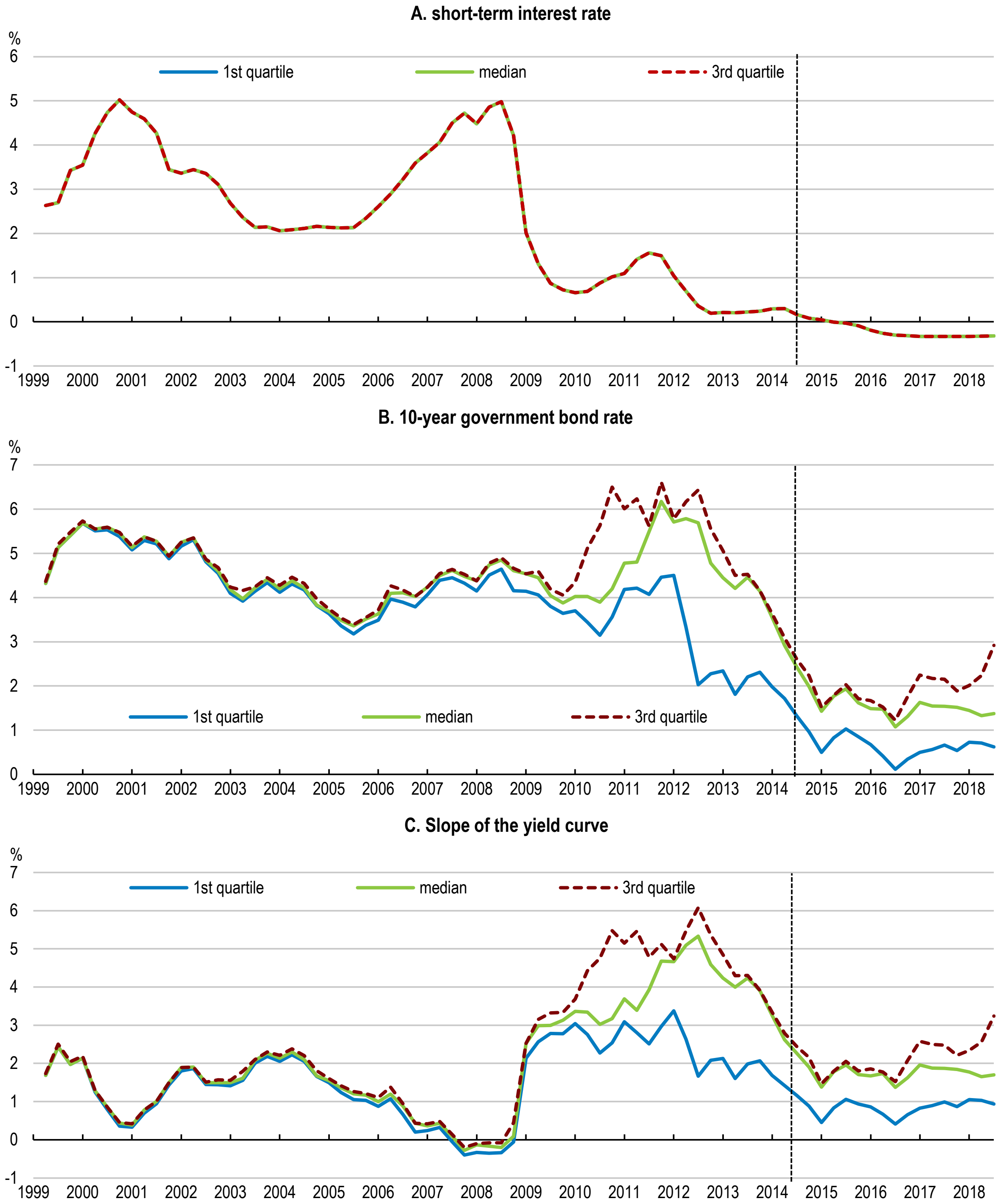
Table A.5. Models of the net interest income to assets (an alternative data source)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable: NII calculated as Int_inc_a less Int_exp_a	Pooled OLS with country and time dummies	Pooled OLS with country dummies	FE with country and time dummies	FE with country dummies	Pooled OLS with country and time dummies	Pooled OLS with country dummies	FE with country and time dummies	FE with country dummies
$NII_{i,c,t-1}$	0.522***	0.536***	0.291**	0.309**	0.523***	0.537***	0.289**	0.298**
	(0.0237)	(0.0229)	(0.132)	(0.140)	(0.0237)	(0.0229)	(0.132)	(0.139)
i_t	-0.00222	0.00899***	-0.00120	0.0122**	-0.00214	0.00997***	-0.000784	0.0115**
	(0.00460)	(0.00271)	(0.00311)	(0.00567)	(0.00463)	(0.00256)	(0.00313)	(0.00562)
$y_{c,t}$	-0.00284	-0.00284*	-0.00421	-0.00505*	-0.00231	-0.000265	-0.00330	-0.00262
	(0.00206)	(0.00169)	(0.00407)	(0.00277)	(0.00241)	(0.00174)	(0.00434)	(0.00242)
D_t*i_t	0.619**	0.141***	0.532**	0.0548				
	(0.252)	(0.0479)	(0.227)	(0.0623)				
D_t*$y_{c,t}$	0.00522	0.00392	-0.00202	-0.00366				
	(0.00450)	(0.00383)	(0.00776)	(0.00564)				
Low_t*i_t					0.0697	0.0479*	0.131***	0.0142
					(0.183)	(0.0269)	(0.0448)	(0.0246)
Low_t*$y_{c,t}$					0.0006	-0.0051**	-0.0030	-0.0079***
					(0.00328)	(0.00225)	(0.00402)	(0.00272)
Constant	0.257***	0.122***	0.465***	0.322***	0.256***	0.115***	0.463***	0.318***
	(0.0763)	(0.0199)	(0.0887)	(0.0688)	(0.0764)	(0.0195)	(0.0899)	(0.0640)
Observations	1,803	1,803	1,803	1,803	1,803	1,803	1,803	1,803
Adjusted R^2	0.489	0.485	0.168	0.158	0.488	0.484	0.169	0.163
Number of groups			45	45			45	45

Note: The variables are defined as follows: NII is net interest income over total assets calculated as a difference between the interest income to assets, Int_inc_A, and the interest expense to assets, Int_exp_A, reported in Bloomberg, i_t is the 3-months interest rate, $y_{c,t}$ is the slope of the yield curve, Low_t is a dummy variable equal to 1 when the 3-month nominal interest rate is below 0.5% and zero otherwise. All models include a constant and bank fixed effect; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. ***, **, and * denote significance at the 1%, 5%, and 10% level.

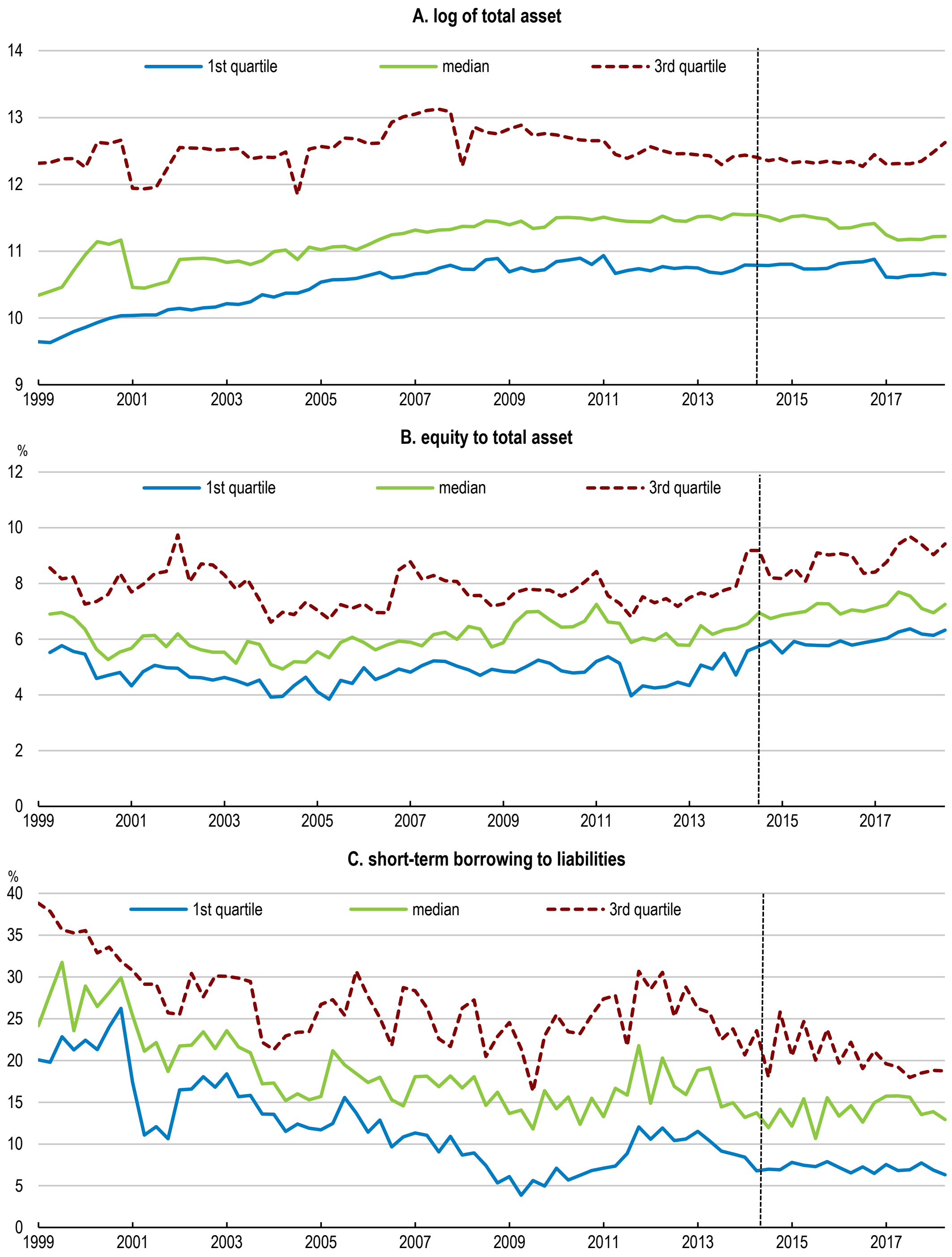
The data used in estimation are charted below. The variation in short-term interest rates (Figure A.1. panel A) reflects the changing composition of the euro area; the variation in the 10-years sovereign bond rates (Figure A.1 panel B) mainly reflects the time-varying country risk premia.

Figure A.1. Interest rates and slope of the yield curve



Note: The vertical line denotes the time when the euro area policy rate turned negative.
Source: OECD Database and calculations

Figure A.2. Main bank-specific variables



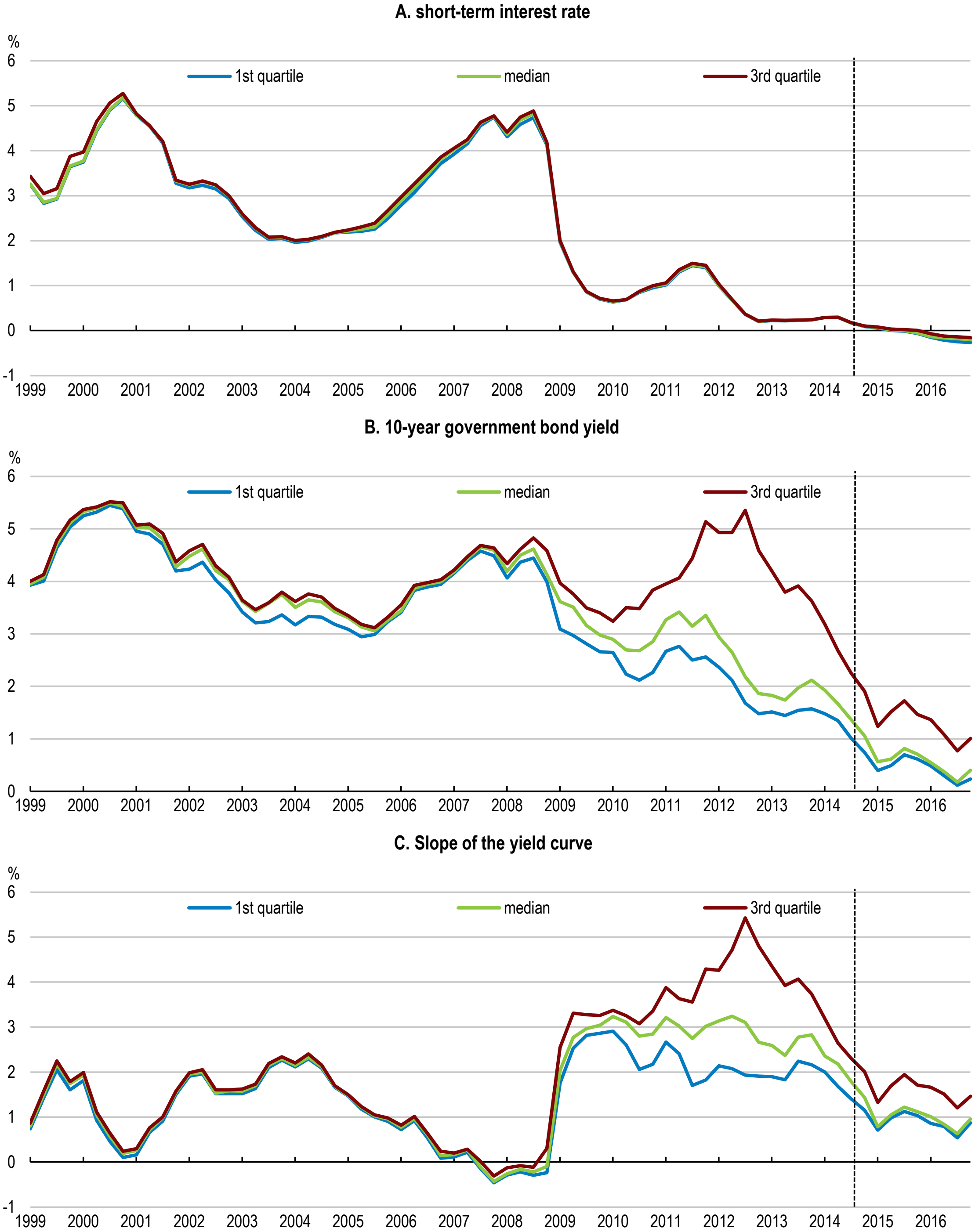
Note: The vertical line denotes the time when the euro area policy rate turned negative
Source: OECD calculations using Bloomberg data

Table A.6. Summary statistics of main variables used in the weighted regression model

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
NIM (net interest income to earning assets)	1,615	.5494727	.4110485	-2.169681	8.232047
NII (net interest income to total assets)	1,653	.4821316	.307948	-1.95627	7.567612
weighted 3 month interbank rate	3,530	2.18727	1.71545	-0.1748	9.18807
weighted slope of the yield curve	3,456	1.96333	2.03987	-2.9979	19.8784
weighted real GDP growth	3,530	0.31152	0.88623	-8.2727	5.74705
weighted nominal GDP growth	3,530	0.73592	0.99453	-7.9169	4.76881
weighted share prices growth	3,461	0.48039	8.91964	-38.96	42.3662
weighted house prices growth	3,470	0.73798	1.81951	-18.24	9.09813
bank leverage	2,319	6.51131	3.08338	-4.899	22.4126
log of total assets	2,319	11.5658	1.60296	5.54983	14.6877

Source: Bloomberg and OECD calculations.

Figure A.3. Weighted interest rates and slope of the yield curve



Note: The vertical line denotes the time when the euro area policy rate turned negative.
Source: OECD Database and calculations.

Table A.7. Net interest income regressions by bank size

Fixed effect models

	(1) Assets below EUR 100bn	(2) Assets above EUR 100bn	(3) Small (below 100bn)	(4) Medium (100bn - 500bn)	(5) Large (over 500bn)
$NII_{i,t-1}$	0.355**	0.0961	0.218	0.0284	-0.0370*
	(0.162)	(0.123)	(0.152)	(0.139)	(0.0139)
i_t	0.00959	0.00900	0.0225*	0.0333***	-0.0575
	(0.00608)	(0.0113)	(0.0125)	(0.0108)	(0.0389)
$y_{c,t}$	-0.00716***	-0.00676	0.00193	-0.00187	-0.0182
	(0.00251)	(0.00532)	(0.00279)	(0.00631)	(0.0236)
D_t*i_t	0.0907	-0.0339	0.0885	-0.0612	0.128
	(0.0581)	(0.0992)	(0.0718)	(0.159)	(0.156)
$D_t*y_{i,t}$	0.00224	-0.0358***	-0.00104	-0.0245***	-0.0539
	(0.00276)	(0.00553)	(0.00491)	(0.00841)	(0.0751)
$ln(A_{i,t})$			-0.0672**	0.110	-0.0223
			(0.0323)	(0.0965)	(0.101)
$E_{i,t}/A_{i,t}$			0.0128***	0.00121	-0.0122
			(0.00464)	(0.00835)	(0.0394)
$SB_{i,t}/L_{i,t}$			-0.000241	-0.00462*	0.00414
			(0.000726)	(0.00241)	(0.00444)
$Prov_{i,t}/A_{i,t}$			-0.0200	-0.0197	0.0185
			(0.0157)	(0.0139)	(0.0513)
$RGDP_{c,t}$			0.00275	-0.00566	-0.0365
			(0.00227)	(0.00472)	(0.0426)
$E\_RGDP_{c,t+1}$			-0.00339	0.00165	0.0747
			(0.00690)	(0.00860)	(0.0795)
$E\_PIEc_{,t+1}$			-0.000126	0.00394	0.00878
			(0.00812)	(0.0104)	(0.0188)
Country Ds	No	No	No	No	No
Time Ds	No	No	No	No	No
Observations	1,122	681	930	433	169
Number of groups	33	20	32	18	5
Adjusted R^2	0.263	0.0407	0.282	0.0504	0.0913

Note: The variables are defined as follows: $NNI_{i,t}$ is the net non-interest income defined as non-interest income less non-interest expense as a fraction of total assets, i_t is the 3-months interest rate, $y_{c,t}$ is the slope of the yield curve, $A_{i,t}$ are total assets, $E_{i,t}$ is total equity, $SB_{i,t}$ is short-term borrowing, $L_{i,t}$ are liabilities (i.e. assets less equity), $Prov_{i,t}$ are provisions against loan losses, $RGDP_{c,t}$ is real GDP growth and $E\_RGDP_{c,t+1}$ and $E\_PIE_{c,t+1}$ are the expected real GDP growth and inflation, respectively. All models include a constant and bank fixed effect; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. The reported adjusted R2 refers to corr(x_(i,t) β̂,y_(i,t)). ***, **, and * denote significance at the 1%, 5%, and 10% level.

Table A.8. Models of interest income and interest expense with additional explanatory variables

Fixed effect models

Dependent variable	(1) $Int\_inc\_a_{i,c,t}$	(2) $Int\_inc\_a_{i,c,t}$	(3) $Int\_exp\_a_{i,c,t}$	(4) $Int\_exp\_a_{i,c,t}$
$LDV_{i,c,t-1}$	0.0558	0.0597	0.434***	0.439***
	(0.135)	(0.135)	(0.0757)	(0.0751)
i_t	0.116***	0.119***	0.0515***	0.0533***
	(0.0335)	(0.0324)	(0.0144)	(0.0146)
$y_{i,c,t}$	0.00804	0.0126**	0.00523	0.00599*
	(0.00597)	(0.00575)	(0.00343)	(0.00308)
D_t*i_t	0.188		0.100**	
	(0.139)		(0.0466)	
$D_t*y_{i,c,t}$	-0.0248*		-0.0104***	
	(0.0126)		(0.00226)	
$ln(A_{i,t})$	-0.0752	-0.0765	0.0288	0.0244
	(0.0572)	(0.0571)	(0.0302)	(0.0303)
$E_{i,t}/A_{i,t}$	0.00276	-0.000992	-0.00606	-0.00791**
	(0.00659)	(0.00581)	(0.00364)	(0.00338)
$SB_{i,t}/L_{i,t}$	0.00229	0.00235	0.000570	0.000442
	(0.00188)	(0.00190)	(0.000743)	(0.000754)
$Prov_{i,t}/A_{i,t}$	-0.00501	-0.00489	0.00159	-8.36e-05
	(0.0195)	(0.0190)	(0.00686)	(0.00715)
$RGDP_{i,c,t}$	0.00216	0.00398	-0.000152	2.44e-06
	(0.00549)	(0.00603)	(0.00208)	(0.00229)
$E\_RGDP_{i,c,t+1}$	-0.0902**	-0.107**	-0.00228	-0.00437
	(0.0422)	(0.0455)	(0.0121)	(0.0132)
$E\_PIE_{i,c,t+1}$	0.0522	0.0470	0.100***	0.0989***
	(0.0832)	(0.0795)	(0.0308)	(0.0296)
Low_t*i_t		0.140*		0.0894***
		(0.0718)		(0.0308)
$Low_t*y_{i,c,t}$		-0.0185***		-0.00430
		(0.00648)		(0.00297)
Constant	1.559**	1.612**	-0.239	-0.182
	(0.679)	(0.666)	(0.326)	(0.325)
Observations	1,580	1,580	1,453	1,453
Number of groups	47	47	45	45
Adjusted R^2	0.244	0.243	0.713	0.711

Note: The variables are defined as follows: Int_inc_a is the interest income to assets, Int_exp_a is the interest expense to asset, i_t is the 3-months interest rate, $y_{c,t}$ is the slope of the yield curve, $A_{i,t}$ are total assets, $E_{i,t}$ is total equity, $Prov_{i,t}$ are provisions against loan losses, $RGDP_{c,t}$ is real GDP growth and $E\_RGDP_{c,t+1}$ and $E\_PIE_{c,t+1}$ are the expected real GDP growth and inflation in a country where the bank is headquartered, respectively. All models include a constant and bank fixed effect; the country and time dummies are included as indicated. The reported standard errors are equivalent to clustering in the panel variable. The reported adjusted R2 refers to corr(x_(i,t) β ̂,y_(i,t)). ***, **, and * denote significance at the 1%, 5%, and 10% level.