Intermediation below zero: The effects of negative interest rates on banks' performance and lending

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INTERMEDIATION BELOW ZERO: THE EFFECTS OF NEGATIVE INTEREST RATES ON BANKS' PERFORMANCE AND LENDING

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Reducing interest rates below zero may be justified on theoretical grounds while, in practice, it is shown to create a number of distortions and malfunctions in several dimensions of banking and financial markets, which in turn may affect the whole economy. This paper surveys international experience of negative interest rates and the existing theoretical and empirical research of the impact on banks. It also investigates the impact of negative interest rates on the European banking sector using a dataset of 3,155 banks from 36 European countries over 2011–2018. Using a difference-in-differences methodology, we show that banks in negative interest-rate environments experienced a 18.4% decrease in their net interest margins compared to other banks operating in European countries that did not adopt negative interest rates. We also show banks taking more customer deposits are more affected.

Non-technical executive summary

This paper investigates the impact of negative interest rates on the banking sector. The aim is twofold. First of all, it surveys the theoretical grounds of unconventional monetary policies and the evidence found in previous studies. Secondly, it provides empirical evidence for the case of European banks under the unconventional policies undertaken by the European Central Bank.

The debate on the effectiveness of unconventional monetary policy has become intense as both the Federal Reserve and the European Central Bank resumed the expansionary stance of monetary policy in 2019. Currently, the lack of consensus on the direction and effects of unconventional measures seem to be substantial. On the one hand, there is some consensus that quantitative easing and low interest rates helped central banks address the circumstances presented by the crisis and the ensuing economic downturn. On the other hand, criticism on these policies has grown. Recent studies suggest there is an effective lower bound (ELB) for interest rate at which monetary policy transmission is not efficient. In practice, negative rates have been shown to have very limited effects in stimulating inflation and/or lending. Empirical studies have shown that, under certain circumstances, low interest rates may even have a 'reversal effect', generating exactly the opposite effect (less lending and depressed expectations on inflation) they initially aimed to achieve. As for banks, the impact of unconventional monetary policy –including negative official rates– has been found to be negative on margins and profitability.

In addition, negative interest rates could have other effects (see table below) beyond those on bank lending and margins. The market structure of financial markets (*e.g.,* proliferation of non-bank and other shadow banking suppliers) and the level of liquidity (*e.g.* liquidity hoarding and short-term liquidity distortions) could be adversely affected. Additionally, the ample use of collateral in unconventional monetary policy has increased the relevance of debt markets and some related financial instability risks. A number of firms that would typically exit or be forced to restructure in a competitive market –"zombie firms"– seem to increasingly survive, in part due to the abundant liquidity and low interest rates. Their resilience reduces average productivity and crowd-out growth opportunities for more productive firms. Negative rates also generate confusing signals to investors on price formation and economic expectations. These effects are effectively generating distortions in liquidity, stock and real estate markets.

Other effects of unconventional monetary policy measures

Effects	*Examples*
Market structure of financial markets and liquidity	• Liquidity hoarding • Distortions in short-term liquidity markets • Proliferation of non-bank and other shadow banking suppliers
Financial vulnerabilities in the corporate sector	• Sustainability of corporate debt • Profitability of pension funds and life insurance • Low quality corporate transactions (including M&A funding)
Stock markets and investment	• Artificial redesign of market structures • Pricing problems • Bank equity negatively affected
Real estate markets	• Cost of housing capital distorted • Liquidity allocations and real estate bubbles • Difficult rate transmission to mortgage-holders

Source: Authors' own elaboration.

As for the empirical analysis in this paper, an examination of net interest margins in the European banking sector since 2012 reveals they have been substantially smaller in the countries that have been affected by negative interest rate policies. In the Euro Area, the decline in interest income has been particularly acute. Using a dataset of 3,155 banks from 36 European countries over 2011–2018 we show that banks in negative interest-rate policy (NIRP) environments experienced a 18.4% decrease in their net interest margins compared to other banks operating in European countries that did not adopt negative interest rates. Banks in NIRP countries experienced a 43.8% fall in their interest income compared to those operating under positive official interest rates. Although interest expenses also fell, they did it to a lower extent (30.3%). Taking together, these findings support the hypothesis of an imperfect pass-through mechanism of negative rates to customers where negative rates affect to a larger extent lending rates than deposit rates, thereby having a negative net effect on interest margins.

We also find that some banks are more negatively affected by negative rates policies than others. Banks holding more liquid assets, highly capitalized and with larger reserves at central banks have experienced a more significant decrease in their interest margins under the negative interest rate environment. Additionally, banks with a larger share of customer deposits has also faced a more significant negative impact.

Finally, we also provide evidence on a larger impact of negative interest rates on net interest margins (-26.40%) of the banks in the core EU economies (Belgium, France, Germany, Italy, Netherlands, Poland, United Kingdom and Spain). These results are found to be consistent to a number of sample, specification and econometric robustness checks.

These findings may contribute to some extent to the current debate on the effectiveness of unconventional monetary policy and on the need of revising the side effects of keeping interest rates low or negative for a prolonged time period. It is not just that they are detrimental for commercial banks, there is also a growing concern that the overall effects in the economy may become negative if rates remain too low for too long. Tracking the impact of unconventional monetary policies in different sides of the financial system seems urgent. Moreover, this monitoring analysis should be also prospective, and consider how changes in pricing and incentives related to low or negative rates may generate financial instability in the near future. Corporate debt sustainability, sovereign to private debt contagion, rise of shadow banking, liquidity hoarding, or distortions in real estate markets should be considered as candidates. Achieving basic funding and investment functions in the financial sector should be incentive-compatible and protracted low interest rates may not be helpful in this front.

"Ice petals on the trees.
The peppery black sparrows pour across
the frozen lawn.
The wind waits patiently behind the barn.

Though I'm not myself here, that's okay.
I've lost my name,
my last address, the problem
that has kept me up all night this week in winter."

Below Zero – Jay Parini *(New and Collected Poems: 1975-2015* - Beacon Press)

1. INTRODUCTION

The impact of the last financial crisis has been only comparable to the size of the responses to battle it. Monetary policy has taken the lead role. A series of extraordinary expansionary measures have been adopted. There have been attempts, at different paces in various geographic locations, to revert the expansionary path but, ultimately, ten years after the crisis the monetary policy at both sides of the Atlantic is still focused on reducing interest rates and providing liquidity to a larger extent than ever before. Within this context, there have been several experiences of official monetary rates being set below 0%. There are historical episodes of negative interest rates but in the last few years, financial life 'under zero' has become more frequent. This has given rise to an intense debate on whether such rates fulfil the purpose they are theoretically intended. Namely, fostering inflation, lending and, ultimately, economic growth. Controversies arise as negative rates have also been found to create, on parallel, problems such as introducing significant distortions, *inter alia,* in financial asset pricing, financial intermediation, cash holdings or real estate investment.

This paper investigates the impact of negative interest rates on the banking sector. The aim of the paper is twofold. First of all, it surveys the theoretical grounds of monetary policy but, mostly, on the empirical evidence shown in different studies. Secondly, it also provides some evidence for the case of European banks in the last few years under the measures undertaken by the European Central Bank.

We explore previous experiences of negative rates in both lending and deposit facilities of central banks in countries like Switzerland, Japan, Sweden or Denmark, as well as the case of the Eurozone as a whole. Although lending and deposit facilities have different goals and scope, they seem to be related. Additionally, most studies show that banks are unequally affected by negative rates within the same monetary area depending on factors such as their reliance on customer deposits. Empirical research has also revealed that there has been confusion around what is the effective lower bound (ELB) that identifies the minimum rate at which monetary policy transmission is still efficient. On top of the limits of rate reductions, it has been also demonstrated that negative rates operate in a dynamic and non-linear setting in which other goals should be considered beyond pure monetary aspect (*i.e.,* the exchange rate). Overall, reducing interest rates below zero may seem a natural way to proceed on theoretical grounds while, in practice, it is shown to create a number of distortions and malfunctions in several dimensions of banking and financial markets.

The paper is structured in four sections following this introduction. Section 2 surveys the main studies on unconventional macroeconomic policies and their effects, with a particular focus on negative interest rates. The sample data and main descriptive statistics are provided in Section 3. Section 4 explains the methodology and the results of the empirical study. Section 5 concludes.

2. BACKGROUND

2.1. The need to revise the macroeconomic policy

The policy actions to battle the financial crisis have been eminently monetary. An intense discussion has been going on in the academia and amongst central bank analysts about the appropriateness and effectiveness of these measures. This has been happening alongside with apparent austerity efforts that have constrained fiscal policies in many countries. Blanchard, Dell'Ariccia and Mauro (2010) reflect on the macro policy lessons that have (and have not) been learned after the crisis. The first conclusion that they reach points directly to the interest rate as the main focus of monetary policy which, however, mostly ignores the complexities of financial intermediation. They believe a relative exception in central bank theoretical models is the consideration of the so-called "credit channel" (reductions in interest rates pushing lending up). They also suggest the last financial crisis has illustrated the typical dual role of central banks as facilitators of such credit channel and, at the same time, as lenders of last resort that are also in charge bank supervision.

Obstfeld and Rogoff (2009) study the causes of the last financial crisis and point to pre-2007 fiscal and monetary policies. They are considered the seed from which other problems evolved. In particular, (too) loose monetary policies that gave rise to (too) low inflation and (too) low interest rates. Blanchard, Dell'Ariccia and Mauro (2010) also consider that "little attention was paid, however, to the rest of the financial system from a macro standpoint." Among these, they mention the macroeconomic facilities that arise when inflation is stable (output, financial assets and credit aggregates may vary substantially despite price stability) and to new features of financial intermediation. As for the latter, many agents operate in financial markets that are linked through arbitrage. They move rapidly from one segment or type of assets to another, causing significant volatility in several market segments, including banking. When these jumps occur, the effectiveness of the monetary official rate is diminished. This has been a matter of concern in the post-crisis environment and, in particular, after various attempts to implement a more contractive monetary policy. Ultimately, central banks have returned to expansionary measures and, in the case of the ECB, to negative interest rates. In this context, Lilley and Rogoff (2019) discuss the limits of monetary policy and negative rates and suggests such problems are particularly acute in the Euro Area:[1]

> *[There is] a case for gradually instituting the changes necessary to implement unconstrained negative interest rate policy as a long-term solution to the zero bound on interest rates (or more precisely the near zero effective lower bound.) We shall argue that if negative interest rate policy can be implemented, it would be by far the most elegant and stable long-term solution to the severe limits on monetary tools that have emerged since the financial crisis. Admittedly, the question of how to resuscitate monetary policy is of more immediate relevance in Europe and Japan, where interest rates are already at the effective zero lower bound (in many cases mildly negative) a decade after the global financial crisis, and more than two decades after Japan's financial crisis. But even the United States is likely to face severe constraints in the event of another financial crisis, possibly even in a deep recession.*
>
> *Implementing effective negative rate policy will require a host of legal, regulatory and tax changes. A considerable amount of time and study is warranted, and the obstacles in different countries may vary.*

[1] See also Agarwal and Kimball (2019) for a wider analysis on how to build a monetary policy that allows a quasi-frictionless policy of negative rates.

Eggertsson, Juelsrud and Wold (2017) analyse the effects of negative policy rates in Sweden, Denmark, Japan, Switzerland and the Euro Area. Using aggregate and bank-level data, they demonstrate a collapse in pass-through to deposit and lending rates once the policy rate turns negative. Additionally, they build a macro-model with a banking sector that links together policy rates, deposit rates and lending rates and show that once the policy rates turn negative, the usual transmission mechanism of monetary policy breaks down. The model suggests that, ultimately, is not just that negative interest rates are not effective, it is also that they can be output contractionary. Specific effects on banks under these international experiences of negative rates are analyzed in the following sections.

The debate on the effectiveness of unconventional monetary policy has become even more intense as both the Federal Reserve and the European Central Bank resumed the expansionary stance of monetary policy in 2019 after suggesting (or even following) a more contractionary path. The lack of consensus on the direction and effects of unconventional measures seem to be substantial. On the one hand, a number of economists suggest unconventional monetary policy helped central banks that used them address the circumstances presented by the crisis and the ensuing economic downturn. Smets and Potter (2019), for example, acknowledge there have been side effects –such as disincentives to private sector deleveraging and spillovers to other countries, but does not consider them sufficiently strong to reverse the benefits of these policies to the economy. On the other hand, criticism has grown and the Eurosystem seems to be the main playground for discussion. Klaas Knot, President of De Nederlandsche Bank (DNB) and member of the ECB's Governing, made a public statement in September 13, 2019, just one day after a meeting of the ECB Executive Committee criticizing the stimulus package approved:[2]

> *This broad package of measures, in particular restarting the asset-purchase-programme (APP), is disproportionate to the present economic conditions, and there are sound reasons to doubt its effectiveness. The Euro Area economy is running at full capacity and wages are increasing. Financing conditions for consumers, businesses and governments are highly accommodative and provide no impediment to credit supply, consumption or investment.*
>
> *Meanwhile, there are increasing signs of scarcity of low-risk assets, distorted pricing in financial markets and excessive risk-seeking behaviour in the housing markets.*

Dissension increased within the ECB after the September decisions. It has even led to a series of atypical public statements and press coverage. Two examples from the press illustrate this conflicting climate. In October 10, 2019, *Financial Times* published an article describing the conflicting nature of some of the monetary decisions.[3] An excerpt:

> *The European Central Bank decided to restart its bond-buying programme last month over the objections of its own officials, a further sign of how the move has reopened divisions within the institution.*
>
> *The bank's monetary policy committee, on which technocrats from the ECB and the 19 eurozone national central banks sit, advised against resuming its bond purchases in a letter sent to Mario Draghi and other members of its governing council days before their decision, according to three members of the council.*

On October 13, Jean-Claude Trichet, former ECB president, reacted to the flow of criticism in another piece published in *Financial Times*.[4] An excerpt:

[2] https://www.dnb.nl/en/news/news-and-archive/Persberichten2019/dnb385535.jsp

[3] *Financial Times* (Oct 10, 2019): https://www.ft.com/content/de4a958a-eab3-11e9-a240-3b065ef5fc55

[4] *Financial Times* (October 13): https://www.ft.com/content/cf6b93f0-ec1d-11e9-aefb-a946d2463e4b

All decisions of the ECB are taken by a majority of the governing council. This is true of the unconventional measures taken under my presidency and my successor Mario Draghi. These actions were necessary and bold – and met with harsh criticism of me and Mr Draghi. When I was president, two of my colleagues on the council resigned over the securities markets programme.

While necessary, unconventional monetary measures have adverse consequences, as well as positive ones. So we should ask first whether central banks are responsible for the abnormal situation of the real economy. And second, what would the counterfactual be had such unconventional measures not been taken?

2.2. Monetary policy and bank lending: The effective lower bound (ELB)

The revision of interest rate-related policies seems to suggest that there should be a (policy effective) limit in reducing interest rates. This threshold is determined by the ability of such rates to fulfil their goal: increasing inflation and/or output. A first important distinction is that central banks may modify the official (main) financing rate and/or the deposit rate that commercial banks pay for their reserves at central banks. While setting zero main financing rates have been relatively frequent, going into negative territory has mostly (though not exclusively) been the case of deposit rates. It is illustrative using a real-case policy discussion of the issue, such as the well-known letter sent by Charles Bean, deputy governor of the Bank of England, to Andrew Tyrie, Chairman of the Treasury Select Committee (Bean, 2013). In a didactic way, Bean explains that in theory, a central bank can set rates at any level, including below zero. When a negative rate is set on deposits (reserves) of commercial banks, this should theoretically encourage them *"to substitute out of them into alternative assets (…) including loans, that would lead to downward pressure on the interest rates on those assets. Eventually, the whole constellation of interest rates would shift down, such that banks were content to hold the existing quantity of reserves."* However, he points out that if the deposit rate were negative *"banks might well prefer to accept a reduction in their profits rather than further reduce deposit rates or increase the charges for such accounts."* Bean refers to the experience of Denmark *"where the Danish National Bank introduced negative remuneration on excess reserves in July 2012 (…) there being little change in household borrowing and deposit rates. That in turn would reduce the impact of the policy easing on aggregate demand."* However, the most interesting insight in Bean's letter is the long-term view:

If, however, the period of negative Bank Rate was likely to be long-lived, it might lead to more substantial changes in behaviour. First, banks might decide to convert their reserves into cash to avoid the charge (…) Second, banks might be more inclined to introduce or raise charges for running current accounts (…) More significantly, if a substantial volume of funds left the banking system it could undermine the system's ability to deliver the basic banking functions of maturity transformation and secure payments transfer.

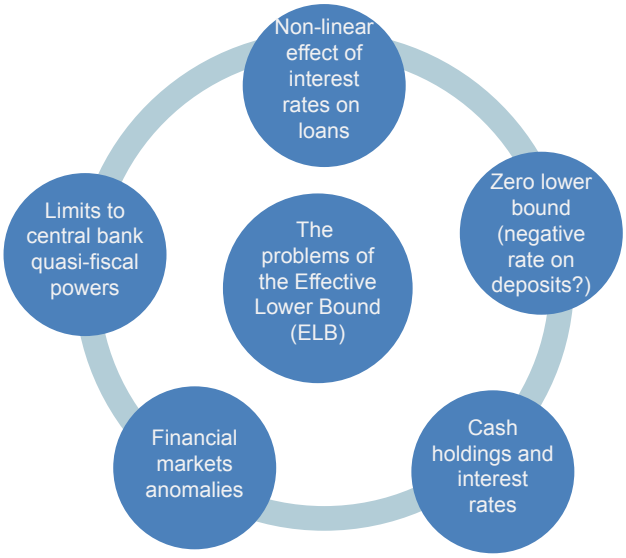
There has been empirical evidence on the constraints imposed by the effective lower bound (ELB). Reza, Santor and Suchanek (2015) summarize the international empirical evidence of most of the studies on the ELB. They show ELB as a limit on the performance of quantitative easing (QE). The general finding is that expanding the central bank's balance sheet through large-scale asset purchases can provide effective stimulus although the effectiveness of QE may be affected by imperfect pass-through to asset prices, possible leakage through global capital reallocation, a reduced impact through the bank lending channel, and diminishing returns to additional rounds of QE. These lessons appear to be particularly relevant for a long-term QE policy where various rounds of expansionary monetary policy have been already implemented. The academia shares the common view that QE has produced more benefits than costs (up to now) but scepticism on the welfare balance increases with the duration of the expansionary measures. One important feature on the long-term perspective is the effect of QE on lending. Brunnermaier and Koby (2017) define the "reversal interest rate" as the rate at which accommodative monetary policy "reverses" its intended effect and becomes contractionary for lending.

They show that this occurs when recapitalization gains from the duration mismatch are offset by decreases in net interest margins, lowering banks' net worth and tightening its capital constraint. Similarly, Arce, García Posada and Mayordomo (2019) explore the effects of the deposit facility of the ECB –that has been negative since June 2014– on lending. They take a sample of 122 banks of 13 Euro Area countries as a reference to analyse if maintaining negative interest rates over a prolonged period can adversely affect credit institutions' net interest income and, ultimately, the supply of credit. Their findings suggest that banks most affected by negative interest rates tightened the terms and conditions on their loans to a greater extent than those unaffected, to optimise their risk-weighted assets and, therefore, their capital ratios. Relatedly, Heider, Saidi and Schepens (2017) also analyse the effects of negative ECB deposit rates on lending and their findings suggest that the introduction of negative policy rates by the ECB led to more risk taking and less lending by euro-area banks with greater reliance on deposit funding. They even suggest that negative rates could pose a risk to financial stability. Borio and Gambacorta (2017) study the effectiveness of monetary policy on bank lending in a low interest rate environment. They use a sample of 108 large international banks. Their results show that monetary policy is less effective in stimulating bank lending growth when interest rates reach a very low level. This could explain why lending remained subdued in 2010-2014 despite the efforts of monetary authorities. Brei, Borio and Gambacorta (2019) also use a similar sample and find similar effects, suggesting also that negative rates are related to a concomitant decline in the risk-weighted asset ratio and a reduction in loan-loss provisions, which is consistent with signs of evergreening in some economies.

Lilley and Rogoff (2019) consider that central banks have been mainly relying on various forms of quasi-fiscal policy when they have faced the limit of the zero lower bound. They show this has opened a discussion on whether *"central banks are wholly-owned subsidiaries of the central government. For example, when central banks purchase long-term government bonds by issuing bank reserves that match the short-term treasury bill rate, this amounts to no more than shortening the maturity structure of the consolidated government balance sheet."* Importantly, they suggest that these "quasi-fiscal powers" of central banks have been helpful during the crisis but they should be limited to this kind of shocks.

Overall, uncertainty remains about the effects of negative rates and the effective lower bound, at least in what lending is concerned (see Figure 1). Although setting negative rates (the starting point of the

Figure 1. Monetary policy and the effective lower bound



Source: Authors' own elaboration.

circle in Figure 1) could be seen as a natural continuum in central bank rate policy, the limits are both practical (*e.g.,* reluctance of commercial banks to pass negative rates to depositors, disruption in financial markets, hoarding of cash in the private sector) and of a political nature (*e.g.,* limits to quasi-fiscal powers of central banks). McAndrews (2015) suggests that even though nominal rates can become negative, zero is still an important benchmark or "lower bound". If negative rates are applied, he considers *"society faces a distinctive set of complications and costs that can blunt the intended good effects of a negative nominal rate policy."* As noted by Reza, Santor and Suchanek (2015) the exact *"effective quantitative bound"* where the costs of QE become larger than the benefits is as yet unknown.

2.3. The effect of negative rates on bank profitability and the scope of a tiered deposit rate system

The effects of unconventional monetary policy –including negative official rates– on banks affects not just lending but also margins and profitability (see the Appendix for a summary of studies covering this topic). The empirical evidence is mixed and relatively recent. Using a similar sample to Borio and Gambacorta (2017), Borio, Gambacorta and Hofmann (2017) examine the impact of monetary policy on bank profitability. The analysis reveals important non-linear effects. First of all, they show there is a positive relationship between the level of short-term rates and the slope of the yield curve. Relatedly, there is an impact of short-term rates on the return on assets (RoA) of banks. Hence, there are two related effects. On the one hand, there is positive impact of the interest rate structure (relationship between the official rate and the yield curve) on net interest income. On the other hand, there is a negative impact of short-term rates on loan loss provisions and on non-interest income. Empirically, the first effect seems to dominate over the second. This implies that when interest rates fall to low, zero or negative levels, an unusually flat term structure erodes bank profitability.

Brunnermeier and Koby (2017) identify some complex structures. They show that keeping low or negative official rates for a long time do not allow bank to access to better funding conditions (*i.e.,* it does not produce recapitalization gains) while still consistently reduce bank margins. They also show that interest rate cuts can have heterogeneous effects across regions where monetary policy operates, being possibly expansionary in one region and contractionary in another. Overall, they suggest that quantitative easing increases the reversal interest rate. Similarly, Eggertson, Juelsrud and Wold (2017) assume a lower bound on deposit rates and banks that are entirely deposit-funded and also predict adverse effects on profits and credit supply, although they also suggest that banks compensate lower interest margins by increasing fee income.

Heider, Saidi and Schepens (2017) further explore the limits in the application of negative rates by monetary authorities. They show that banks are reluctant to pass on negative rates to depositors, which increases the funding cost of high-deposit banks, and reduces their net worth, relative to low-deposit banks. This implies that prolonged QE measures may have limited long-term effectiveness and negative effects on financial instability. They even suggest that "negative policy rates have the potential to change the role of banks for the supply of credit to the real economy."

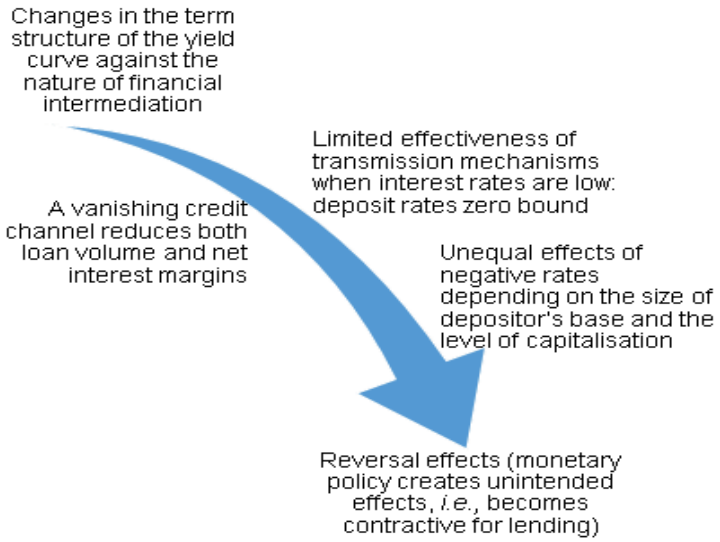
Other studies offer alternative explanations. Arce, García Posada and Mayordomo (2019) exploit the information of the Euro Area banks' responses to the Bank Lending Survey (BLS) and classify banks into two groups, depending on whether their net interest income has been impaired by negative rates ("affected" banks) or not ("unaffected" banks). Their findings suggest the affected banks are generally not as well capitalised and this affects their capacity to take more risk and increase lending under monetary stimulus. They show, however, there are no differences between affected banks and unaffected banks in the amount of total credit offered because credit supply has been adapted via

loan terms and conditions and not through the total amount offered. Overall, their assessment is that negative rates on the deposit facility of the ECB have had not negative impact on credit supply. Similar evidence if found by Demiralp, Eisenschmidt and Vlassopoulos (2017) use individual bank data to explore the impact of negative interest rates in the Euro Area through three channels: government bond holdings, bank lending, and wholesale funding. Their results suggest there is significant adjustment of banks' balance sheets during the negative interest rate period: banks tend to extend more loans, hold more non-domestic government bonds and rely less on wholesale funding. However, they also show that the effects depend on banks' business models. Consistent with other evidence, banks with a higher reliance on deposits are particularly affected. Overall, their assessment is that the charge on excess reserves seemed to encourage banks to take action to avoid it, thereby catalysing more active portfolio rebalancing.

For the purpose of this study, the case of Spain is particularly relevant. Martínez (2017) investigates how the net interest income of Spanish banks evolved under ECB interest rates.[5] Before the crisis, the trend of net interest income was upward for a large period (from 1987 to 2008 in the study). From 2008 onwards, there was a downward trend that coincided with the period in which policy interest rates have been declining and ultimately, the deposit rate was set below zero. He suggests, however, there is no evidence (at least not from a correlation point of view) of a relationship between net interest income and official short-term interest rates. Importantly, the net interest income is examined corrected from the impact of changes in the NPL ratio and the volume of lending. This would, for example, make the interest margin in 2016 (less volume and less margin) look very similar to that of 2003 (more volume and more margin). In any event, he documents a narrowing trend for interest margins since 2015, which is in line with the reduction in the official short-term rate.

Pérez and Ferrer (2018) study the sensitivity of the profits and balance sheet structure of Spanish banks to changes in the level of interest rates during the 2000-2016 period. The evidence is somehow mixed. On the one hand, they find a non-linear relation between interest rates and net interest income, which is positive at low interest rate levels. On the other hand, different profit measures also present a non-linear relation with interest rates, which can be negative even for low interest rate levels if

Figure 2. Central bank negative rates: five related effects of bank lending and profitability



Source: Authors' own elaboration.

[5] Recall also that interest rate floors (minimum rate) on mortgage contracts have been mostly eliminated in Spain.

provisioning charges are high enough. Part of the identification problem, as shown by Martínez (2017) is that a negative volume effect may be exogenous to banks (a reduction in demand for lending) but may also be a consequence of their own decisions on loans (tighter lending conditions in order to preserve margins). Figure 2 summarizes the main effects of negative rates on lending and bank margins.

Eggerston, Juelsrud and Wold (2017) show how negative central bank deposit rates have affected banks in different monetary areas. In Sweden, the central bank set the deposit rate at negative levels in February 2015. Bank deposit rates, however, either did not move or decrease slightly but remained above zero. In Denmark, the central bank set a negative rate in July 2012 and also in September 2014. It was neither transmitted to deposit rates. The lack of transmission of negative rates to deposit rates was also observed in Switzerland (with rates entering in negative territory in December 2014) and Japan (negative rates set in March 2016). The Euro Area case is particularly interesting because, when the ECB reduced it deposit rate below zero in June 2014, aggregate deposit rates were high in the Euro Area and had more room to fall. In any event, the bank deposit rate seemed bounded by zero. As noted by Bean (2013) when central bank rates are already close to zero, the transmission to the real economy of any further rate reduction is likely to be more muted than normal. Consistent with the evidence shown in other monetary areas, he suggests that English lenders are typically reluctant to reduce deposit rates below zero while many of the bank loans are linked to the official rate directly or indirectly through LIBOR. The falls in funding costs are followed by falls in interest income compressing banks' net interest margins and reducing profitability. He suggests that a middle way emerges to reduce the adverse impact of negative central bank deposit rates on banks' profitability which is tiering deposit rates. That is, applying the official rate only to a fraction of bank reserves at the central bank, while other fractions been charged higher rates. This is particularly feasible in environments where the central bank requires banks to hold minimum reserves proportional to the size of their deposits over total assets, as the ECB or the Federal Reserve. As banks frequently keep more reserves that officially required at central banks (excess reserves) these could be remunerated at a different rate. This has motivated the ECB in particular to consider such system. As the ECB president Mario Draghi stated on July 25 2019:

> *If the medium-term inflation outlook continues to fall short of our aim, the Governing Council is determined to act, in line with its commitment to symmetry in the inflation aim. It therefore stands ready to adjust all of its instruments, as appropriate, to ensure that inflation moves towards its aim in a sustained manner.*
>
> *In this context, we have tasked the relevant Eurosystem Committees with examining options, including ways to reinforce our forward guidance on policy rates, mitigating measures, such as the design of a tiered system for reserve remuneration, and options for the size and composition of potential new net asset purchases. (…) "We have to have the committees' work and decide how to design the system.*

One of the experiences of tiered deposit negative rates is Switzerland. Basten and Mariathasan (2018) analyse this case by comparing changes in the behaviour of banks that had different fractions of their central bank reserves exempt from negative rates, as it happened in the Swiss tiered system. They show that more affected banks reduce costly reserves and bond financing while maintaining non-negative deposit rates and larger deposit ratios. They also show that these banks managed to compensate the squeeze of interest margins with higher fees. However, they also observe that credit and interest rate risk increase. The policy action in Switzerland followed these steps:

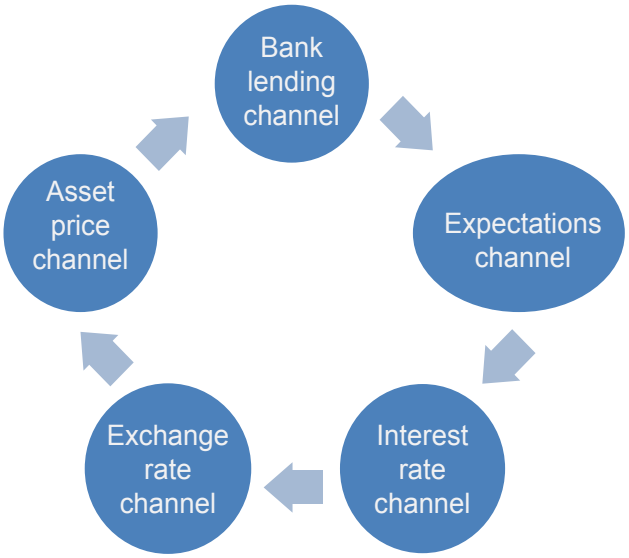
- Traditionally, the Swiss Central Bank defined upper and lower bounds for the target interbank rate and injected or extracted liquidity from the market. No interest was paid for bank reserves.

- In the years that followed the financial crisis, the upper and lower bounds were moved various times and the lower bound entered negative territory in December 2014. It also announced a -0.25% rate on banks' sight deposit account balances.

- On January 15, 2015, the rate announcement was lowered further to -0.75%. The central bank set limits to the reserves that were charged and those that were exempted, thereby generating a two-tiered system.

While the Swiss experience is an example that a two-tier system may work, it also was designed under a very particular exchange rate environment. Specifically, the Swiss National Bank removed the franc peg system *vis-à-vis* the Euro so that both the protection of the exchange rate and the two-tier system had an effect on banks that it is not easy to disentangle.

Figure 3. Channels of the pass-through of monetary policy



Source: Authors' own elaboration.

2.4. Other effects on banks, markets, and consumers

Negative interest rates and other related unconventional monetary policy actions could have other effects beyond those on bank lending and intermediation margins. It is important to keep in mind there are different –but not mutually exclusive– ways of the pass-through of monetary policy actions (see figure 3).[6]

The bank lending channel (the main reference in figure 3) operates when changes in interest rates (also other open market operations) generate changes in bank liquidity and prices that modify lending and, subsequently, aggregate investment, economic growth and inflation.

The interest rate channel works through inflation expectations. Any change in the official rate that modifies inflation expectations may imply changes in the cost of capital and on investment demand. A similar but wider way of pass-trough is the expectations channel. The short-term interest rate decisions of central banks and their forward guidance (information of the monetary policy intentions in the long-

[6] A survey on how the effectiveness of these channels may have diminished in recent years can be read in Hannoun (2015).

run) generate expectations on future monetary policy movements that can also have implications on inflation, investment and growth.

There is also an asset price channel that relates monetary policy decisions to financial markets and private sector wealth. This may operate by increasing asset prices when interest rates decrease. It may also occur when lower rates encourage consumers and firms to borrow or to expend more.

Finally, there is a connection between movements in interest rate and the exchange rate, where lower (higher) rate generally pushing the exchange rate up (down).

Hence, any change in interest rates can have multiple impacts on the economy that are not easy to identify at the same time. Ultimately, the effects that are not directly related to banking but to other relevant parts of the financial system architecture could be even more difficult to estimate when rates go negative. As shown in Table 1, we consider four (non-necessarily exclusive) areas: a) effects on the market structure of financial markets and liquidity; b) increase of financial vulnerabilities in the corporate sector; c) impact on stock markets and investment; d) distortions on real estate markets.

Table 1. Other effects of unconventional monetary policy measures

Effects	*Examples*
Market structure of financial markets and liquidity	• Liquidity hoarding • Distortions in short-term liquidity markets • Proliferation of non-bank and other shadow banking suppliers
Financial vulnerabilities in the corporate sector	• Sustainability of corporate debt • Profitability of pension funds and life insurance • Low quality corporate transactions (including M&A funding)
Stock markets and investment	• Artificial redesign of market structures • Pricing problems • Bank equity negatively affected
Real estate markets	• Cost of housing capital distorted • Liquidity allocations and real estate bubbles • Difficult rate transmission to mortgage-holders

Source: Authors' own elaboration.

2.4.1. Effects on the market structure of financial markets and liquidity

Most of central bank monetary decisions rely on dynamic general equilibrium models. Financial intermediation has been only recently incorporated to these models. Specifically, Gertler and Karadi (2011, 2013) analyse the relationship between financial intermediation and unconventional monetary policy measures within a general equilibrium framework. Importantly, they consider a wide definition of intermediation that includes both the interbank market and aspects of the shadow banking sector. Shadow banking is defined as "credit extension outside of the banking system" (FSB, 2011) and it includes institutions such as hedge funds, money market funds, pension funds, or insurance companies, whose importance have continuously increased after the Great Recession. Hence, commercial banks are no longer the only intermediaries to channel funds from savers to investors, but shadow banks, thereby altering the dynamics of the model. As noted by Moe (2012), quantitative easing has increased the "collateral manufacturing" of central banks and this has prepared the build-up of leverage in both the banking and the shadow banking system. Banks could use their high quality collateral to obtain repo-financing, thereby providing pledgeable collateral for re-allocating it in the shadow banking system. Shadow banks typically fund themselves with securities lending transactions. It has been an empirical observation that liquidity movements are much larger in key markets such as the repo, and some liquidity tensions are even generating crunches in the repo markets.[7] As suggested by Gertler and Karadi (2011)

[7] See, for example, the actions undertaking by the Federal Reserve in October 2019, resuming "the purchases of short-term US Treasury bonds to expand its balance sheet in hopes of preventing a repeat of the recent disruption in overnight "repo" markets": https://www.ft.com/content/f228f44c-e9f6-11e9-a240-3b065ef5fc55

the problem is that any malfunction of breakdown in market liquidity leads to even more requests for central bank interventions. All in all, central banks appear in the current architecture of liquidity markets as offering unlimited and cheap insurance, thereby enhancing moral hazard.

Breedon and Turner (2016) further explore the changes that reinforced liquidity from quantitative easing has had on liquidity markets. They suggest it implies an increase in transaction costs. They show that most quantitative easing programmes primarily involve central banks acquiring government liabilities in return for central bank reserves. In all cases this process is undertaken by purchasing these liabilities in the secondary market rather than directly from the government. The only practical difference between secondary market purchases and bilateral central bank/Treasury operations is the larger transactions costs involved in market operations attached to quantitative easing.

The challenges of negative rates affect also more fundamental microeconomic grounds of liquidity such as cash holdings and exchange rate stability. Lilley and Rogoff (2019) indicate that no country has tackled how to prevent paper currency hoarding as a feature of protracted policies of negative interest rates. They consider that such preventive policies against hoarding are necessary, *inter alia,* to protect bank profitability. Their main recommendation is to eliminate the hoarding problem by setting and electronic currency that becomes the unit of account, and creating a crawling peg between electronic currency and paper currency. This may imply, *inter alia,* progressively eliminating high-denomination notes, a feature that has proven difficult and to require substantial time. Agarwal and Kimball (2019) acknowledged the difficulties in setting a crawling peg as legal and competences issues may make it difficult for a central bank to formally have an exchange rate between two different currency instruments that it issues.

Jensen and Spange (2015) analyse the behaviour of cash holding after the Danmarks Nationalbank set the rate of interest on certificates of deposit at -0.75% in February 2015. With some similarities to the Swiss case, the decision was intended to defend the Danish fixed exchange rate. They find that negative interest rates did not weaken the pass-through from official interest rates to money market rates. They report that negative interest rates were not fully passed through to bank deposit and lending rates to households although large deposits from firms and institutional investors are extensively paying negative interest rates. As for cash, the effects of negative interest rates can be theoretically circumvented by holding cash, which always offers a nominal return of zero. However, they show that holding large amounts of cash entails substantial costs, including costs for secure storage and transport. Their analysis reveals there was no evidence that cash in circulation was affected by negative interest rates to any significant degree. This led them to conclude that the lower bound on monetary policy rates in Denmark is lower than the current interest rate on certificates of deposit of -0.75 per cent. However, they also suggest that banks may react and begin settling accounts in cash to a great extent, and this could weaken the Danish central bank ability to influence the krone exchange rate. It would be also paradoxical to observe an increase in cash holdings in a Nordic country that was clearly advancing towards a quasi-non-cash status. The Danish case is also examined by Hüttl (2014). She suggests the main goal of the negative rate setting was achieved, as it limited capital inflows and helped to push back the exchange rate of the Danish krone toward the central parity. However, she also shows that rate cut did not lead to changes in retail interest rates, nor an increase in bank lending.

2.4.2. Increase of financial vulnerabilities in the corporate sector

The ample use of collateral in unconventional monetary policy has increased the relevance of debt markets and some related financial instability risks. The *Global Financial Stability Report* of the IMF (International Monetary Fund, 2019) identified some of them and highlighted some disturbing figures:

Corporate bond spreads are very low by historical standards and appear to be compressed relative to fundamentals, reflecting primarily strong investor risk appetite. According to an IMF staff model, rising corporate debt, weaker economic fundamentals, and higher economic uncertainty all imply that spreads should be wider (….) Declining interest rates have led to outflows from loan mutual funds and inflows into bond funds, further suppressing bond yields. Stretched valuations often precede economic downturns and can be an additional source of vulnerability.

(…)

Despite notable declines in Europe and Japan, corporate vulnerabilities remain significant in several countries. The estimated share of speculative-grade debt in total corporate sector debt is now nearly 50 percent in China and the United States and is even higher in Italy, Spain, and the United Kingdom, despite notable declines since the global financial crisis. Furthermore, the share of debt-at-risk in total corporate sector debt is above 25 percent in the United Kingdom and the United States.

The consequences are also highlighted by the IMF managing director (Georgieva, 2019):

Prolonged low rates also come with negative side effects and unintended consequences. Think of pension funds and life insurance companies that are taking on more risky investments to meet their return objectives. In our surveillance, we see such an increase of risk taking by investors broadly around the globe. All of this creates financial vulnerabilities. In some countries, firms are using low rates and building up debt to fund mergers and acquisitions instead of investing. Our new analysis shows that if a major downturn occurs, corporate debt at risk of default would rise to $19 trillion or nearly 40 per cent of total debt in eight major economies. This is above the levels seen during the financial crisis.

(…)

So we need macroprudential tools. And we can use new approaches to better manage debt, reduce financial booms and busts, and contain volatility.

The deputy manager of the Bank for International Settlements also referred to debt levels and their relationship with unconventional monetary policy in a very illustrative way (Hannoun, 2015), with a particular focus in the case of the Euro Area:

Bond market prices in the euro zone may no longer adequately reflect the risk inherent in record high debt levels. At the same time, equity prices are artificially inflated as investors are forced into increasingly risky assets. All this involves the risk of a major correction when confidence in inflated valuations is lost. The question is not whether this will happen again, but when. Of course, nobody can say when the next "Minsky moment", a generalised loss of confidence in artificially inflated valuations, will occur. Yet there is no doubt that the probability and severity of another financial crisis is increased by the prolongation of ultra-low or negative rates.

Advocates of ultra-low or negative interest rates argue that macroprudential tools can be used to offset/ mitigate the financial risks and distortions resulting from ultra-easy monetary policy. Unfortunately, this is not a realistic approach, for two reasons. First, it is better to think of macroprudential policy and monetary policy as complements, not substitutes. Second, three major regulatory reforms that could to some extent mitigate the financial stability risks resulting from ultra-low interest rates are still under discussion. These are the calibration of the leverage ratio for banks in Basel III, the introduction of a Pillar 1 capital charge for the interest rate risk in the banking book, and the equally urgent elimination from EU bank regulation of the zero risk weight for sovereign exposures.

A source of financial instability emerges from the concerns that an increase in the cost of debt for troubled firms may turn them to 'zombies'. As shown by Andrews and Petroulakis (2019) a number

of firms that would typically exit or be forced to restructure in a competitive market –"zombie firms"– seem to increasingly survive during and after the crisis, in part due to the abundant liquidity and low interest rates. Their resilience reduces average productivity and crowd-out growth opportunities for more productive firms (Adalet McGowan, Andrews and Millot, 2018; Caballero, Hoshi and Kashiap, 2008). It has been also argued that accommodative policy increases the incentives of banks to bet on the resurrection of zombie firms (White, 2012) and that "too low for too long" policies make funding cheap and fuel the survival of weak firms, increasing misallocation and harming productivity growth (Borio, 2018).

Banerjee and Hofmann (2018) also refer to the problems related to zombie firms. Its analysis directly points at the negative interest rate environment as enhancing the proliferation of corporate debt related problems. They use firm-level data on listed firms in 14 advanced economies, and document an increase in the prevalence of zombies since the late 1980s. Their findings suggest that this increase is linked to reduced financial pressure (mainly, to lower interest rates). They conclude that the economic impact is already significant as zombies weigh on economic performance because they are less productive and because their presence lowers investment in and employment at more productive firms.

2.4.3. Impact on stock markets and investment

Unconventional monetary policy and, in particular, negative interest rates, introduce a number of legal, operational, and economic frictions in equity markets. As described by McAndrews (2015):

> *It implies redesigning debt securities; in some cases, redesigning financial institutions; adopting new social conventions for the timeliness of repayment of debt and payment of taxes; and adapting existing financial institutions for the calculation and payment of interest, the transfer and valuation of debt securities, and many other operations. These innovations will require considerable time, resources, and effort. A benefit-cost analysis thus must weigh the potential advantages of negative rates against the costs of pushing back the tide of all of these conventions and institutions that have proven useful under positive nominal interest rates. That calculation likely will differ across countries, across institutional environments, and across the expected levels and duration of negative rates.*

It is important to keep in mind that any changes in stocks or debt can also affect banks, as holders and managers of such assets. Ampudia and Van de Heuvel (2018) analyse the effects of monetary policy on the equity values of European banks. Their results show that an unexpected decrease of 25 basis points on the short-term policy rate increases banks' stock prices by about 1% on average. The effects are non-linear over time and are more significant and of wider magnitude during periods of financial instability. Importantly, they show that these effects have *"reversed during the recent period with low and even negative interest rates. That is, with rates close to or below zero, further interest rate cuts became detrimental for banks' equity values."* In line with other studies, these effects are found to eb larger for banks with a high reliance on deposit funding and this may be explained by the reluctance of banks to pay negative interest rates on retail deposits.

Garbade and McAndrews (2015) emphasize the peculiar behaviour of interest-bearing securities when interest rates are negative and how market participants react to such environments. They show that issuers of securities tend to design novel assets as they did in other historical times when interest rate environment was challenging. That was the case, for example of the late 1970s and early 1980s when interest rates reached historically high levels. Agents issued single payment zero-coupon securities then. They show that there could be multiple ways of issuing interest bearing securities that avoid the need for an issuer to collect interest when rates are negative, but *"the real challenge may be to choose a design that suits investors as well as issuers."*

It is important to consider the difference between the impact of quantitative easing on the functioning of equity markets (including investors' expectations) and the reaction of stock indices to QE

announcements. Balatti *et al.* (2018) study the effectiveness of both the QE of the Federal Reserve and of the Bank of England. They use vector autoregression models and show that, in the short-run, the response of equities and liquidity to QE is negative and positive for volatility. In the medium-term, stocks rise and volatility declines. This implies that markets have accommodated to QE in the long-run, despite the impact on their efficiency and price formation.

2.4.4. Distortions on real estate markets

The real economy can also be affected by changes in perceptions over real estate under negative or low interest rate environments. Mishkin (2007) identifies the channels that connect monetary policy to real estate prices. He shows how monetary policy actions directly affect the cost of housing capital, expectations of future house-price movements, housing supply; and indirectly influence the real economy through standard wealth effects from house prices, balance sheet, credit-channel effects on consumer spending, and balance sheet, credit-channel effects on housing demand. These channels may have different implications for real estate prices and mortgages when interest rates are negative.

A relationship between monetary policy and housing bubbles was already identified before the crisis. Jarocinski and Smets (2008) examine how monetary policy affects the housing market by analyzing US housing prices and investment. The results indicate that a loose monetary policy has a significant, positive effect on residential investment and housing prices. Similarly, other studies (Wudud, Bashar and Ahmed, 2012; Tse, Rodgers and Niklewski, 2014; Luciani, 2015) have investigated the sources of the fluctuations in the first decade of the 2000 and find that monetary policy shocks contributed to both the boom and bust in housing. Amzallag *et al.* (2019) also analyse the behaviour of mortgage lenders and show that when policy rates turn negative, banks with higher ratios of retail overnight deposits to total assets charge more on new fixed rate mortgages. They also show that the aggregate economic implications for households are small, suggesting that concerns about inefficient monetary policy transmission to households under modestly negative rates are likely overstated. Basten and Mariathasan (2018), however, find that negative rates motivate that rates stop being transmitted to depositors, which also breaks the transmission to mortgage rates.

Some more recent experiences of house pricing bubbles related to monetary policy have been also identified outside the US and the Euro Area. Xu and Chen (2012) analyze the Chinese housing market and find the housing price growth rate was positively correlated with a loose monetary policy. They find that policies of decreasing long-term interest rates, increasing the money growth rate and loosening mortgage down payments could all positively affect the housing price growth rate. Similarly, Zhang (2013) examine the relationships among Chinese housing price inflation, consumer price index (CPI), and monetary policy and find the housing sector should be taken into account when considering the effectiveness of monetary policy.

3. THE EVOLUTION OF INTEREST RATES: SAMPLE DESCRIPTION

3.1. Negative interest rates: International experience

Since the Great Recession, central banks adopted monetary policy decisions that, *inter alia,* included reductions of the policy interest rates. Some central banks have gone further by adopting zero or even negative interest rates mainly to stabilize inflation expectations and support economic growth. As Table 2 shows, there are currently 33 countries with interest rates below 1%. Most of these countries are located in Europe –where the ECB, and the central banks of Sweden, Denmark and Switzerland have taken unconventional monetary policy decisions– and in the Asia-Pacific Region. Some of those central banks adopted these rates few years ago, mainly from 2016 onwards. Consequently, most of these economies are becoming used to operate in a low interest rate environment.

Table 2. List of countries with official interest rates below 1%

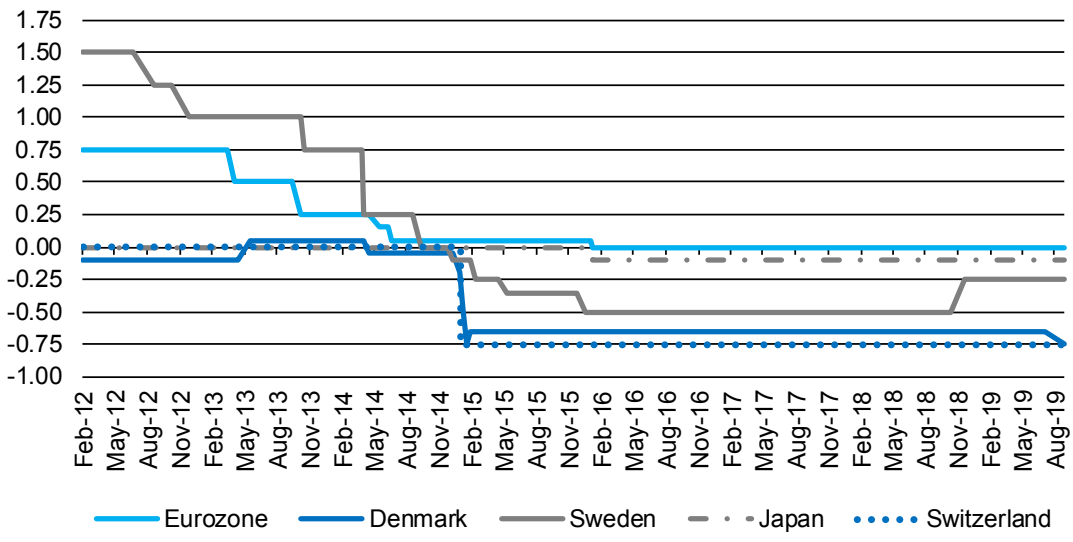
Country/Area	*Policy Interest Rate*	*Date of last change*
Switzerland	-0.75%	15/01/2015
Denmark	-0.75%	13/09/2019
Sweden	-0.25%	20/12/2018
Japan	-0.10%	29/01/2016
Euro Area	0%	10/03/2016
Bulgaria	0%	29/01/2016
Samoa	0.19%	01/06/2016
Israel	0.25%	26/11/2018
Jamaica	0.50%	28/08/2019
Fiji	0.50%	02/11/2011
United Kingdom	0.75%	02/08/2018
Australia	0.75%	01/10/2019
Hungary	0.90%	24/05/2016
New Zealand	1%	07/08/2019
Albania	1%	06/06/2016
Total number of countries	*33 countries*	

Source: Authors' own elaboration.

Figure 4 shows the evolution of the policy interest rates for those countries that have adopted zero or even negative interest rates. This figure reveals the ECB and the Central Bank of Sweden gradually reduced their interest rates from 2012, hitting the zero lower bound later than other central banks.

The Swedish central bank lowered its key policy rate below zero in January 2015. Similarly, from January to February of 2015, rates experienced a cut of 50 basis points in Denmark.

Figure 4. Evolution of policy interest rates (2012-2019)



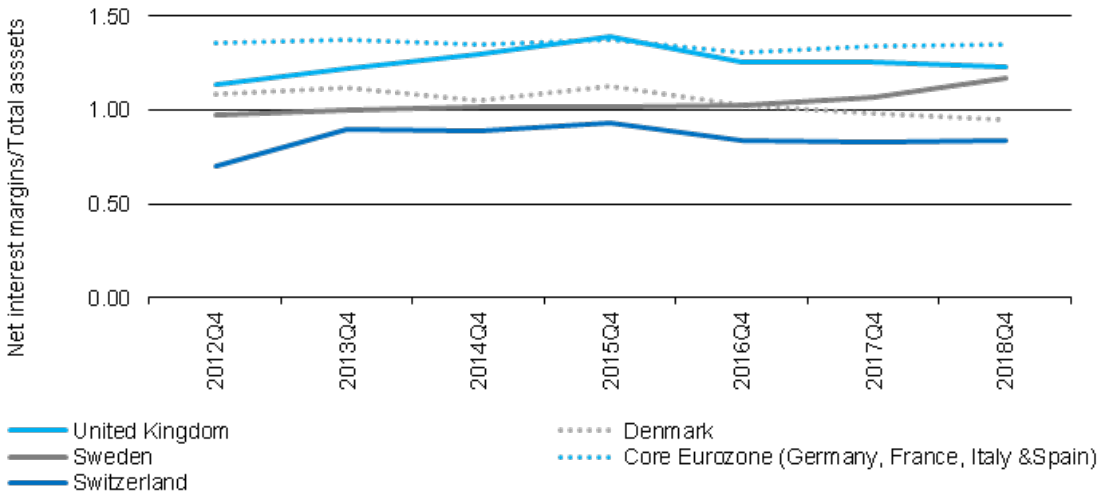
Source: Authors' own elaboration.

3.2. Banks' interest margins under the Zero-Lower Bound

3.2.1. Interest margins in the European banking system

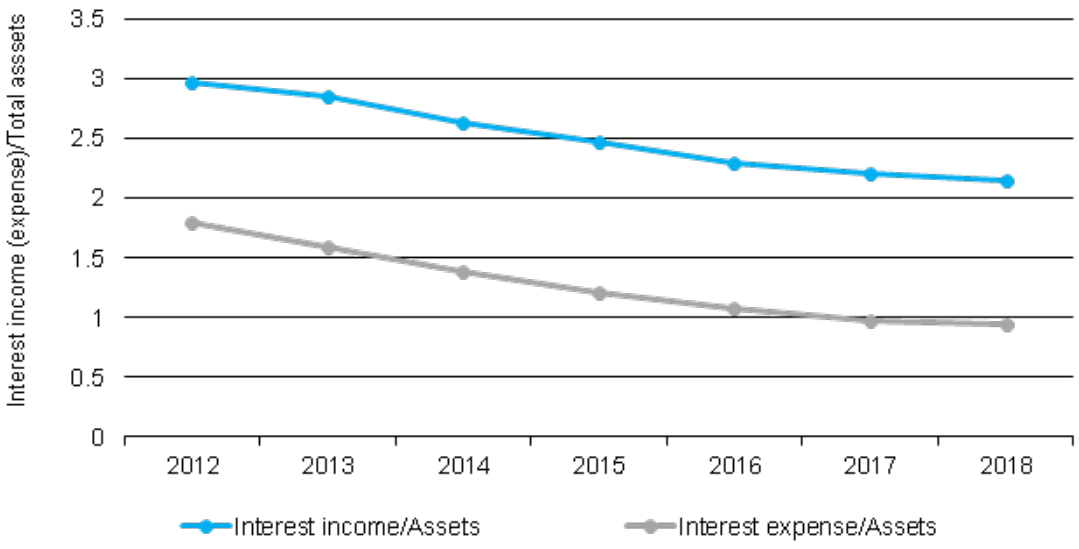
As Figure 5 shows, bank margins have been relatively flat in Europe since 2012. Margins have been smaller, around 1% in terms of total assets, in those countries that have adopted negative interest rates earlier – Sweden, Denmark and Switzerland. In the core countries of the Eurozone and United Kingdom they have been around 1.3% of total assets.

Figure 5. Evolution of net interest margins ratio in the European banking system



Source: Authors' own elaboration.

Figure 6. Evolution of interest income and expenses in the Eurozone



Source: Authors' own elaboration.

Figure 6 distinguishes the evolution of interest income and interest expenses in the Eurozone. Since 2012 interest income, weighted by total assets, have decreased around 1%. In 2012, it represented around the 3% of the total assets, while in 2018 it was closed to 2%. This implies a 27% decrease of net interest income during 2012-2018, a 5% annual fall on average. There has been also a decrease of interest expenses, which have gone from 1.7% to 0.95% during the same period.

3.2.2. Evolution of interest margins by bank specific characteristics

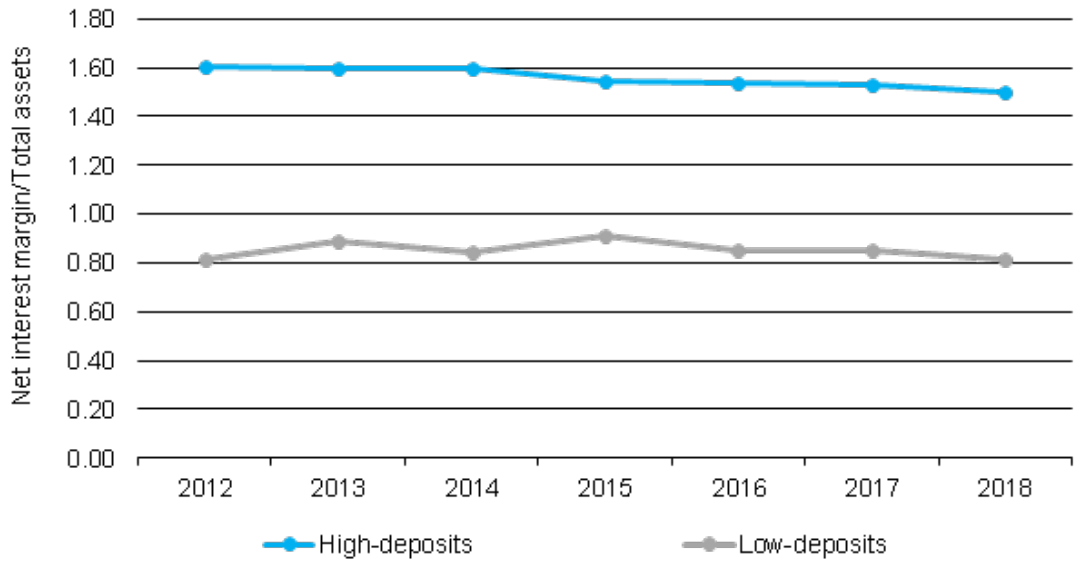
Prior studies have shown that the intensity of the impact of negative interest rates might be stronger for some banks depending on their business profile. We consider four dimensions: deposit funding structure, capitalization, liquidity and assets' quality. All the bank-level information has been retrieved from Orbis BankFocus. Our data set consists of balance sheet and income statement variables for 3.478 Eurozone banks – commercial banks, saving banks and cooperative banks operating in the Eurozone between 2012 and through 2018. The database allows us to examine on detail the effects of negative rates on banks that differ along these dimensions.

3.2.2.1. High-deposit banks vs. Low-deposit banks

We classify banks as high-deposit or low-deposit by computing the ratio of customer deposits to total assets. We identify a bank as high-deposit if that ratio exceeds the sample's weighted (by bank size) average. Otherwise, it is considered as low-deposit.

Figure 7 shows the evolution of net margins by level of deposits while Figure 8 shows the evolution distinguishing for interest income and expenses. In terms of net interest margins, high-deposit banks net margins decreased 7% (from 1.61% to 1.50%), while for low-deposits banks net margins decreased 0.27%.

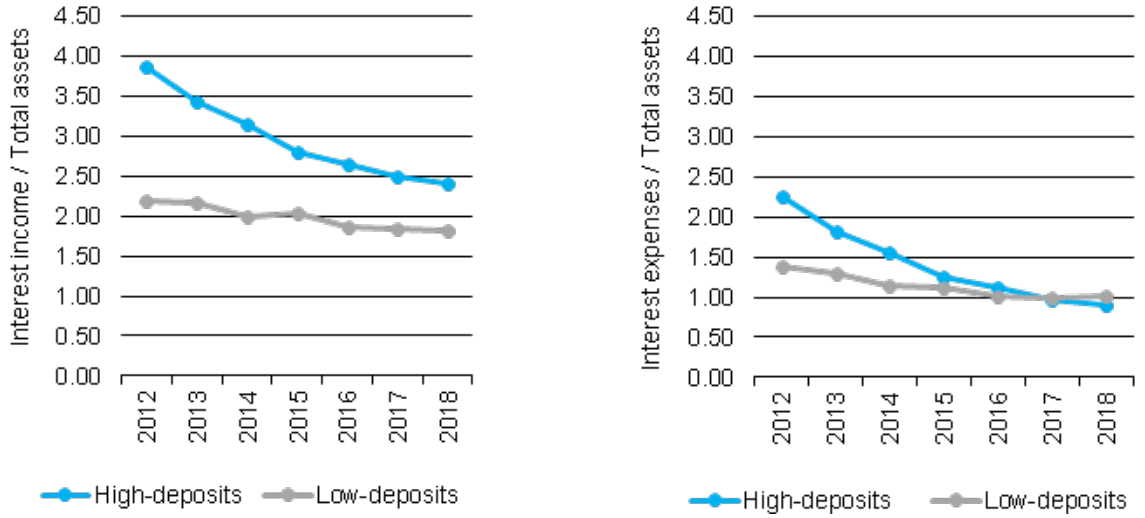
Figure 7. Net interest margins by level of deposits



Source: Authors' own elaboration.

Figure 8 reveals that high-deposit banks have experienced a substantially larger decline in their interest income during 2012-2018. For these banks, interest income ratio fell 37% (from 3.87% in 2012 to 2.41% at the end of 2018). This means an average annual decrease of of 7.6. Similarly, interest

Figure 8. Interest income and expenses by level of deposits



Source: Authors' own elaboration.

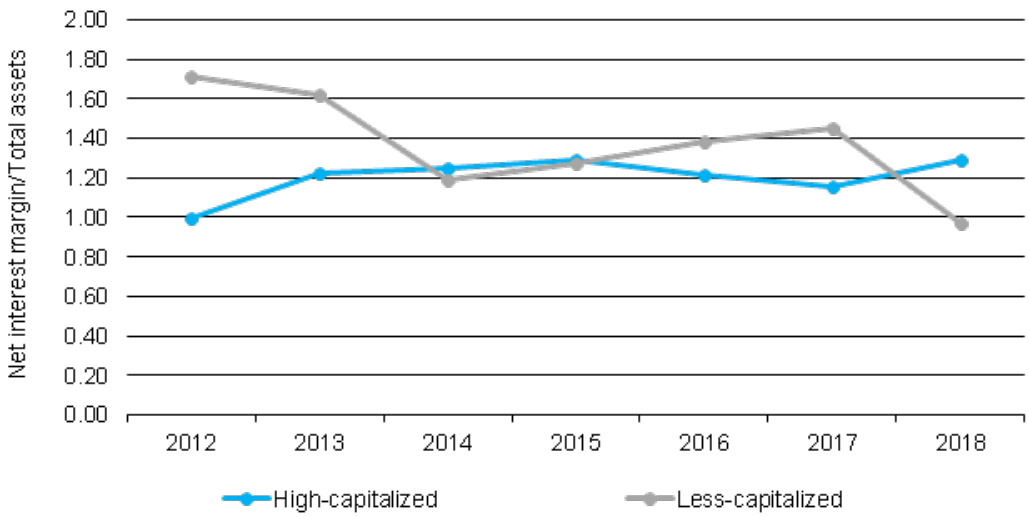
expenses have also decreased more for high-deposit banks (from 2.26% to 0.91%) than for low-deposit banks (from 1.38% to 1%). These facts, as prior literature suggests, could provide preliminary evidence of a stronger effect of a low interest environment for banks with a large base of customer deposits.

3.2.2.2. High-capitalised banks vs. Less-capitalized banks

The impact of a low interest environment could be different depending on the level of capitalization. Molyneaux, Reghezza and Xie (2019) show a substantially larger decline in lending by less-capitalized banks after the introduction of negative interest rates. We identify a bank as high-capitalized banks if its Tier 1 ratio exceeds the sample's weighted (by bank size) capitalization ratio. Otherwise, it is considered a less-capitalized bank.

Figure 9 shows that while high-capitalized banks slightly improved their interest margins, less-capitalized banks experienced a decline in their margins (from 1.71% to 0.97%). Although both groups

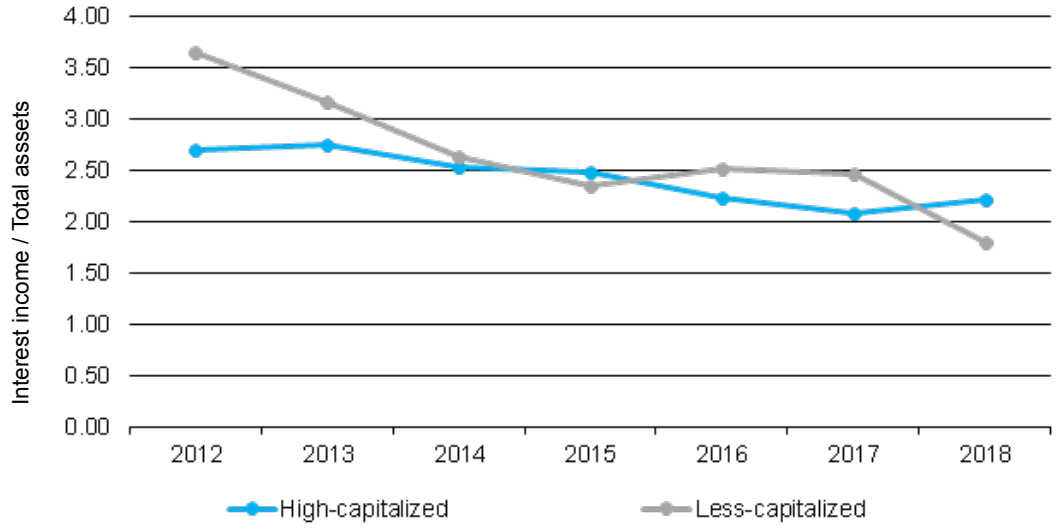
Figure 9. Net interest margins by level of capitalisation



Source: Authors' own elaboration.

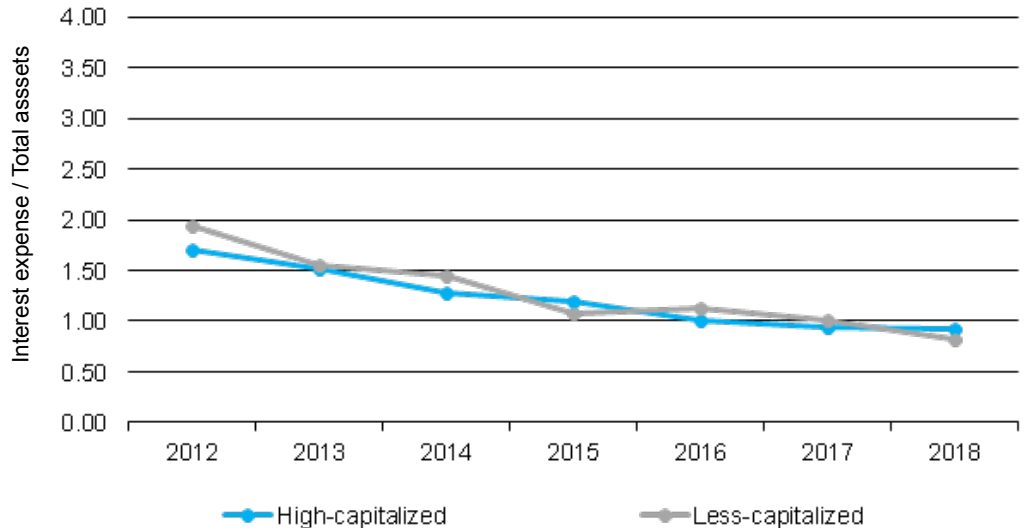
of banks experienced a decrease in their interest income, less-capitalized banks suffered a larger decline (-51% from 2012 to 2018) compared to high-capitalized banks. As for interest expenses, the declines have been similar to both groups.

Figure 10a. Interest income and expenses by level of capitalisation



Source: Authors' own elaboration.

Figure 10b. Interest income and expenses by level of capitalisation

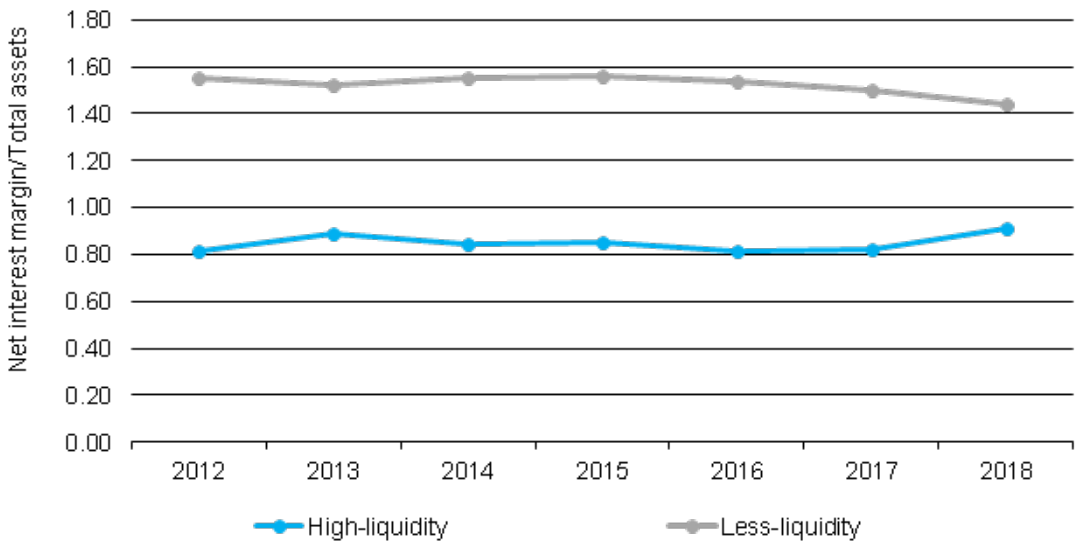


Source: Authors' own elaboration.

3.2.2.3. High-liquidity banks vs. Less-liquidity banks

We identify a bank as a large-liquidity institution if its liquidity ratio (liquid assets to total assets) exceeded the sample's weighted (by bank size) liquidity ratio. Otherwise, it is labelled as less-liquidity bank.

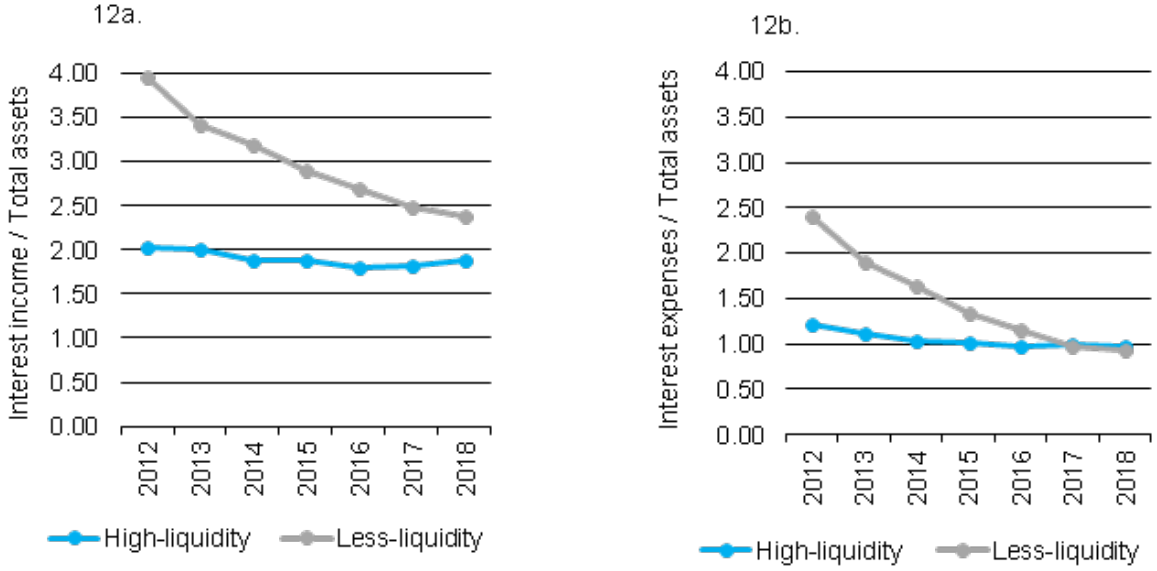
Figure 11. Net interest margins by level of liquidity



Source: Authors' own elaboration.

According to Figure 11, there are not significant differences between high and low liquid banks in the evolution of their net margins. For both type of banks, net margins stagnated (around 1.5% for less-liquidity and around 0.9% for more-liquidity). However, Figure 12 reveals that less-liquidity banks show less stability in both interest income and interest expenses than large-liquidity banks.

Figure 12. Interest income and expenses by level of liquidity

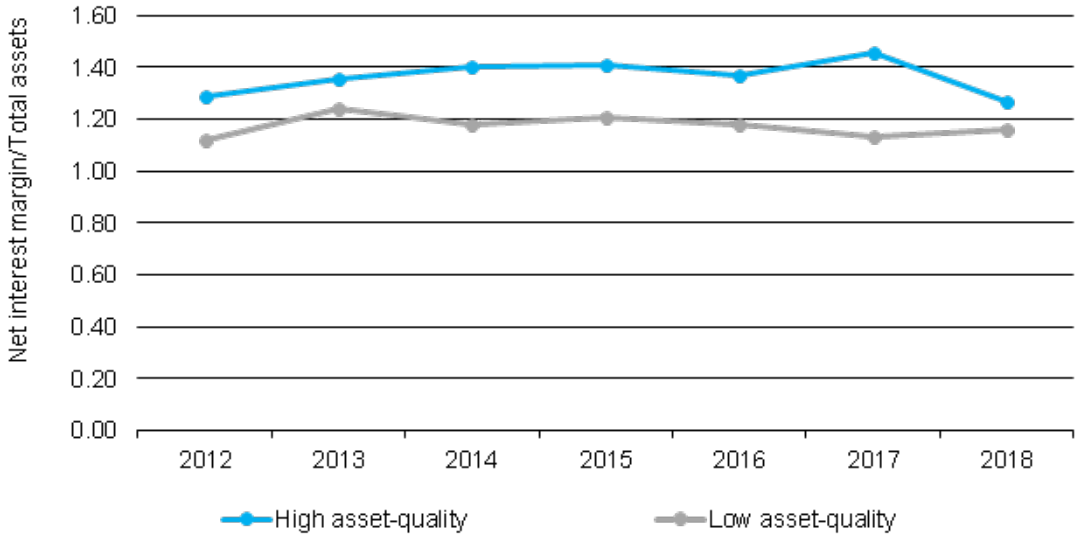


Source: Authors' own elaboration.

3.2.2.4. High-asset-quality banks vs. Less-asset-quality banks

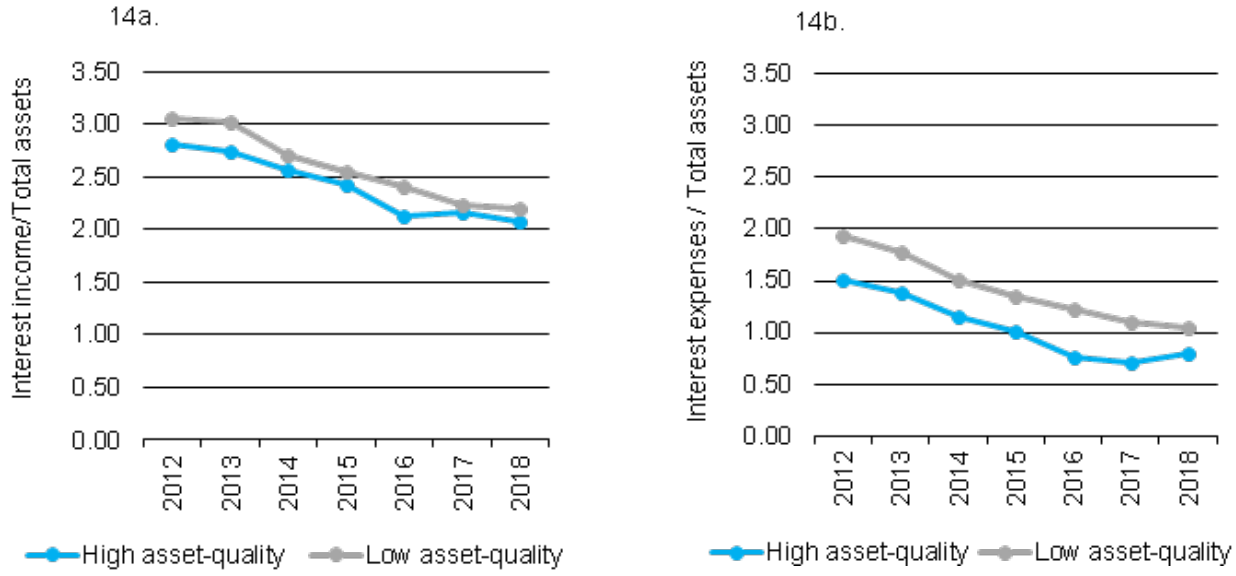
We also examine the evolution of bank margins by asset quality. In doing so, we compute the ratio of impaired loans to total loans. We consider a bank as high-asset quality if the ratio of impaired loans is below the sample's weighted (by bank size) ratio. Otherwise, it is included in the less-asset quality group.

Figure 13. Net interest margins by assets quality



Source: Authors' own elaboration.

Figure 14. Interest income and expenses by assets quality



Source: Authors' own elaboration.

Figure 13 shows that interest margins have been relatively similar for both groups of banks during 2012-2018. In terms of the components of the net margins, Figure 14 reveals that both income and expenses declined.

4. EMPIRICAL ANALYSIS: THE IMPACT OF NEGATIVE INTEREST RATES IN EUROPE

4.1. Data

We examine the impact of official interest rates on bank margins for a sample of banks operating in 36 European countries over the period 2011-2018. The central banks that adopted negative interest

Table 3. List of countries, number of banks, and adoption dates

Countries	*N° of banks*	*Adoption of negative interest rates (as in Jobst and Lin, 2016)*	*Median Net Interest Margin (2011-2018)*
Albania	7	-	3.84
Austria	35	June - 2014	1.77
Belarus	13	-	6.67
Belgium	15	June - 2014	1.28
Bulgaria	16	January - 2016	3.44
Croatia	16	-	3.21
Cyprus	25	June - 2014	3.97
Czech Republic	17	-	2.23
Denmark	61	July - 2012	3.26
Estonia	8	June - 2014	2.46
Finland	175	June - 2014	1.20
France	82	June - 2014	1.42
Germany	1,305	June - 2014	2.05
Greece	7	June - 2014	2.76
Hungary	11	March - 2014	2.75
Iceland	6	-	1.26
Ireland	8	June - 2014	2.08
Italy	396	June - 2014	1.95
Latvia	12	June - 2014	2.06
Lithuania	6	June - 2014	2.22
Luxembourg	13	June - 2014	0.90
Malta	5	-	2.14
Netherlands	19	June - 2014	1.44
Norway	103	September - 2015	1.18
Poland	33	-	2.96
Portugal	105	June - 2014	2.00
Romania	20	-	3.68
Russia	271	-	6.72
Slovakia	8	June - 2014	2.83
Slovenia	11	June - 2014	2.23
Spain	39	June - 2014	1.69
Sweden	75	February - 2015	1.79
Switzerland	104	January - 2015	1.24
Turkey	31	-	4.33
Ukraine	24	-	6.38
United Kingdom	73	-	1.35
Total	3,155		1.97

Source: Authors' own elaboration.

rates did so between 2014 and 2016. Our sample includes 3,155 institutions (commercial banks, saving banks, cooperative banks, investment and private banks) that were active during the whole sample period. Our primary data on bank balance sheet are retrieved from Orbis Bank Focus. We also include information on country-specific variables from the World Bank and the Bank for International Settlements.

We date the adoption of negative interest rates following Jobst and Lin (2016). They consider that a country has adopted a negative interest rate if any of the policy rates for overnight lending, open market operations or deposit facility has gone below zero. This would explain why all the countries

belonging to the Euro Area are considered as negative interest rate policy (NIRP) adopters since June 2014. The 11th of June of 2014 the European Central Bank lowered the deposit rate for excess bank reserves while keeping the main policy rate close to zero. As shown in Table 3, all countries of the Euro Area together with Bulgaria, Denmark, Hungary, Norway, Sweden and Switzerland are included as adopters of negative interest rates.

4.2. Methodology

As prior empirical literature (Berger, Makaew and Roman, 2018; Berger and Roman, 2015; 2017; Duchin and Sosyura, 2014; Molyneaux, Reghezza and Xie, 2019; Montgomery and Takahashi, 2014), we employ a difference-in-differences (DID) methodology to capture the effect of zero and negative interest rates policy (NIRP) on bank margins. This methodology allows us to compare those banks that have been operating with zero or negative interest rates (NIRP) to those that have never experienced such interest rate policy. We employ the following equation:

$$Net\ Bank\ Margin_{ijt} = \alpha + \beta_1\ NIRP\ effect_{ijt} + \beta_2\ X_{Bank\text{-}specific\ variables} + \beta_3\ X_{Country\text{-}specific\ variables} + \beta_4\ Year_t + \beta_5\ Country_j + \varepsilon_{ijt}$$

The dependent variable is the net interest margin of bank "i" in country "j" at time "t". NIRP effect is the DID term (Post-Treatment $Period_{jt}$ x NIRP $bank_{ij}$) which takes the value 1 if bank "i" in country "j" has been affected by a zero or negative interest rates after the implementation of the policy, 0 otherwise. $X_{Bank\text{-}specific\ variables}$ is a vector of variables bank-level variables obtained from balance sheet data and $X_{Country\text{-}level\ variables}$ is a vector of variables reflecting cross-country heterogeneity. We also include year fixed effects –to account for potential time-variant shocks over the sample period– and country fixed effects – to account for time in-variant country effects over the sample period. Furthermore, as is common practice in the literature, the standard errors reported are robust to heteroscedasticity. Since the variance of the error term may be larger for some banks with specific characteristics, we cluster the standard errors by banks.

Naturally, in the DID methodology the control group must be a valid counterfactual for the treatment. We compute the t-tests for the difference in GPD growth and inflation between the two groups of banks. We specifically focus on these two variables since central banks interest policies are focused on stabilizing inflation expectations and supporting economic growth. The average annual GDP for the adopters is 2.08 while for non-adopters in 2.55. In terms of inflation, the average inflation index is 1.32 for adopters while it is 2.20 for non-adopters.

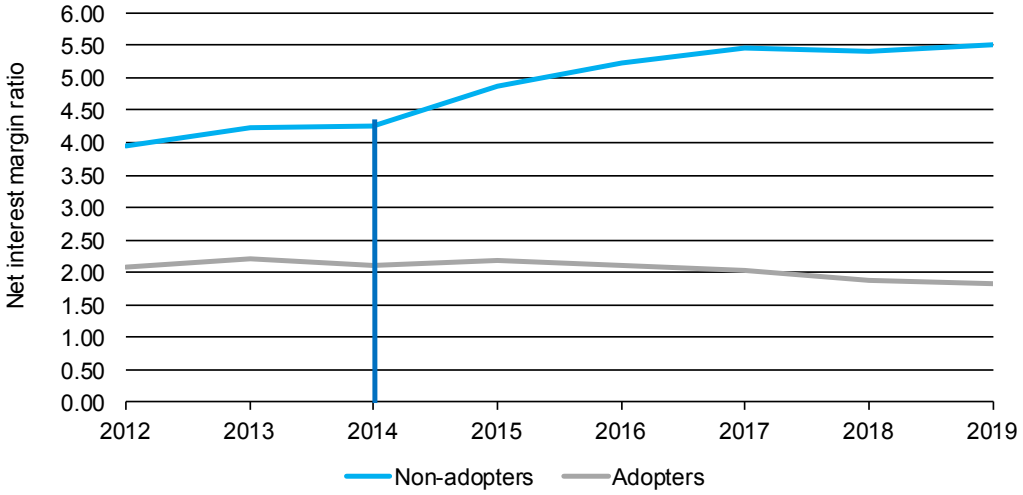
4.3. Variables

4.3.1. Dependent variables: Net interest margin, interest income, and interest expenses

Our main dependent variable is the net interest margin. It is computed as the ratio of net interest income to average earning assets. Figure 15 shows the evolution of net interest margins during the whole period for both types of banks. Both adopters and non-adopters exhibit similar trends until 2014 when the policy rates in most of the NIRP adopters turned negative. After the adoption of NIRP policies, net interest rates fall below 2% for those banks affected by the adoption of negative interest rates while they increase up to 5.5% for those banks operating in countries with positive interest rates. This pattern confirms that the parallel trend assumption is satisfied. Furthermore, the correlation among both group of banks in the pre-NIRP period for the net interest margins is 0.57, while in the post-NIRP period is -0.77.

To gain further insights into the evolution of interest margins, we also aim to examine the impact of negative interest rates by analysing the evolution of its components: interest income and interest

Figure 15. Evolution of net interest margins for adopters and non-adopters



Source: Authors' own elaboration.

expenses. They are both computed as the ratio of interest (expenses) to average interest earnings (bearing) assets (liabilities).

4.3.2. Explanatory variables: Bank-specific variables

We employ a set of financial ratios to account for the different characteristics of the banks: size, liquidity, efficiency and capital adequacy. Bank size is measured by total assets. To account for a possible non-linear relationship between net interest margin and bank size, we include the square value of bank size. As in prior studies that examine bank margins, we also account for the level of liquidity –measured as the ratio of liquid assets to total assets– efficiency –measured as the cost-to-income ratio– and asset quality- measured as the ratio of impaired loans to average risk weighted assets (RWAs).

The ratio of total equity to total assets is used as proxy for the level of bank risk aversion or capitalization. Since margins could be affected by the banks' lending policies, we also consider the growth of bank loans as the annual growth in gross customer loans and advances. As in Molyneaux, Reghezza and Xie (2019), we also control for the level of cash and balances that banks hold at central banks –measured as the ratio of cash and balances at the central bank to total assets– and for taxation –measured as the ratio of taxes to operating income.

4.3.3. Explanatory variables: Country-specific variables

In order to control for macroeconomic conditions, we consider the GDP growth, inflation and the total size of domestic credit to GDP. We also take into account institutional features that may affect bank margins as the existence of a public credit registry or a private credit bureau that inform lending decisions (Credit Info) and the degree to which collateral and bankruptcy law protect the lenders' rights (Legal Rights). These variables are retrieved from the World Bank's Doing Business Database. They are computed as indexes but using different using different scales (Credit Info from 0 to 8 and Legal Rights from 0 to 12). For consistency purposes, we re-scale them from 0 to 1.

Table 4. Descriptive statistics

	Size	*Liquidity*	*Efficiency*	*Asset Quality*	*Total equity to total assets*	*Loan Growth*	*Reserves at central banks*	*Bank taxation*	*GDP growth*	*Inflation*	*Domestic credit to GDP*	*Credit info*	*Legal Rights*
						Non-adopter							
mean	35600	28.83	68.95	10.31	15.99	8.11	11.93	4.43	1.86	5.63	68.43	0.89	0.53
median	1561,677	23.60	62.39	4.99	11.82	4.61	8.85	4.71	2.23	3.56	56.03	0.88	0.58
sd	164000	20.10	48.83	16.27	16.81	37.75	12.38	10.71	2.61	6.49	32.60	0.07	0.19
						Adopter							
mean	18200	14.71	70.77	7.02	10.02	6.92	2.97	6.22	1.64	0.91	92.59	0.89	0.43
median	868.2244	9.77	69.36	3.39	9.29	4.00	1.34	6.84	1.93	0.91	79.01	0.88	0.50
sd	123000	13.84	27.16	12.21	4.77	25.07	5.71	7.89	1.38	0.97	28.96	0.14	0.16
	Size	*Liquidity*	*Efficiency*	*Asset Quality*	*Total equity to total assets*	*Loan Growth*	*Reserves at central banks*	*Bank taxa-tion*	*GDP growth*	*Inflation*	*Domestic credit to GDP*	*Credit info*	*Legal Rights*
						Pre-treatment period							
mean	39000	22.98	67.92	9.99	13.36	7.37	8.05	4.48	0.82	3.96	82.50	0.86	0.50
median	1452.571	17.12	63.77	5.63	10.37	3.02	4.56	4.84	1.39	2.45	77.90	0.88	0.50
sd	184000	19.15	41.17	13.82	13.98	39.08	11.10	10.48	2.67	5.39	35.42	0.11	0.20
						Treatment period							
mean	15100	14.71	71.29	6.72	10.06	6.99	3.02	6.42	1.92	0.83	91.41	0.90	0.42
median	834.1102	9.76	69.86	3.19	9.35	4.17	1.40	7.07	2.14	0.81	79.01	1.00	0.50
sd	108000	13.82	27.16	12.48	4.43	22.42	5.75	7.54	0.98	0.92	28.71	0.13	0.15

Source: Authors' own elaboration.

Table 4 provides the summary statistics for the variables by adoption of negative interest rates policies and treatment period.

4.4. Baseline results

The DID estimations are presented in Table 5. Column 1 reports the results for the regression on bank net margins, while Columns 2 and 3 present the results for the regression on interest income and expenses, respectively.

In Column 1, the negative and statistically significant coefficient of the NIRP effect (DID term) implies that the interest margins of banks operating under negative interest rate have been significantly and negatively affected by the implementation of these rate decisions. Furthermore, these results are economically meaningful, since a bank affected by negative interest rates have experienced an

Table 5. Baseline regressions

Variables	*Net Interest Margin (NIM)*	*Interest Income*	*Interest Expenses*
Negative int. rate (DID term)	-0.184**	-0.438***	-0.303***
	(0.110)	(0.135)	(0.0591)
Size	-8.97e-10**	-1.29e-09**	3.20e-10
	(3.96e-10)	(5.46e-10)	(3.25e-10)
$Size^2$	4.40e-19**	5.00e-19**	-2.19e-19
	(1.90e-19)	(2.55e-19)	(1.51e-19)
Liquidity	-0.0240***	-0.0388***	-0.0169***
	(0.00299)	(0.00305)	(0.00210)
Efficiency	-0.00334***	-0.00403***	-0.000294
	(0.00107)	(0.00100)	(0.000608)
Asset quality	0.00755*	0.00303	-0.00227
	(0.00400)	(0.00441)	(0.00250)
Total equity to total assets	0.0825***	0.0286***	-0.0146***
	(0.0135)	(0.0100)	(0.00455)
Loan growth	-0.00287**	0.00437***	0.00199***
	(0.00112)	(0.00135)	(0.000588)
Reserves at central banks	0.0895***	0.0855***	-0.00411
	(0.0198)	(0.0170)	(0.00450)
Bank taxation	-0.00171	-0.00722**	-0.00103
	(0.00388)	(0.00298)	(0.00517)
GDP growth	-0.0122	-0.0235	-0.0498***
	(0.0265)	(0.0304)	(0.0159)
Inflation	-0.00434	0.0598***	0.0621***
	(0.0120)	(0.0151)	(0.0122)
Domestic credit to GDP	-0.00864**	-0.00687	0.00158
	(0.00426)	(0.00531)	(0.00292)
Credit info	-0.535	2.728***	2.463***
	(0.604)	(0.845)	(0.609)
Legal rights	2.826***	4.078***	1.799***
	(0.706)	(0.824)	(0.361)
Year fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Observations	13,609	13,607	13,584
R-squared	0.529	0.694	0.682

Note: *, ** and *** denote statistically significant at 10, 5 and 1 per cent, respectively.
Source: Authors' own elaboration.

average 18.4% decrease in interest margins compared to banks operating in countries that did not adopted negative interest rates.[8]

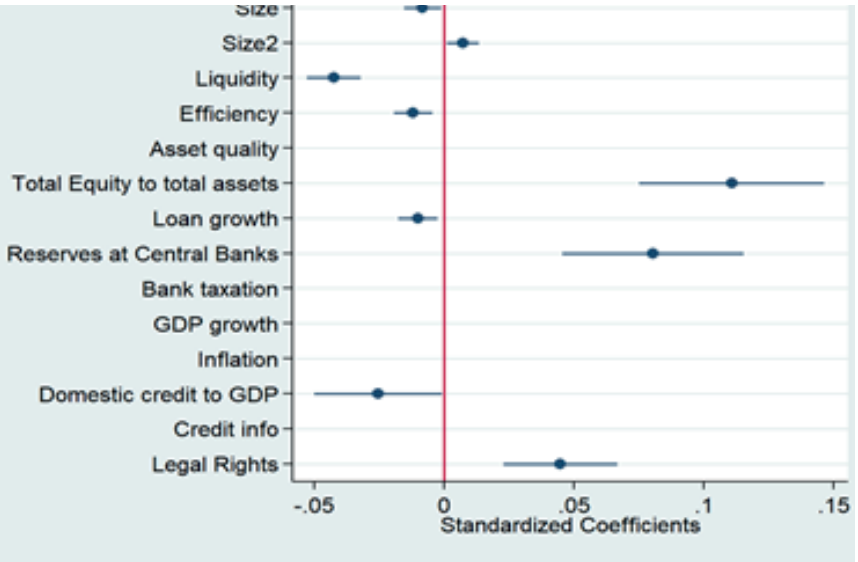
Turning to the determinants of bank margins, the results suggest a non-linear impact of bank size on bank margins. The negative and statistically significant coefficient of Bank size and the positive and statistically significant coefficient of the square of Bank size suggest a convex relationship. The positive coefficient of the ratio of equity to total assets suggests a positive and significant relationship between capitalization and margins. There also seems to be a negative relationship between liquidity and interest margins. As for the negative coefficient of Loan Growth, it seems that increasing loan supply also have detrimental effects on margins under a negative rate environment. The negative coefficient of the cost-to-income ratio suggests that more cost-efficient banks seem to have larger interest margins.

Regarding the country-level determinants of bank margins, we find that banks operating in countries with a larger fraction of domestic credit to GDP seem to have lower interest margins. Similarly, margins are lower in the countries with more stringent bankruptcy law. Table 6 sums up the effects of the main determinants of the net interest margins.

Column 2 reports the results where interest income is the dependent variable and column 3 those where the dependent variable is interest expenses. The negative and statistically significant coefficient of NIRP effect (DID term) in the interest income equation suggest that after the implementation of negative rates, banks in NIRP countries experienced a 43.8% fall in their interest income compared to those operating under positive official interest rates. However, interest expenses did not decrease by the same percentage for those banks under a negative interest rate scenario, in particular interest expenses decreased by 30.3% compared to banks not affected by negative rates. Taking together, these findings support the hypothesis of an imperfect pass-through mechanism of negative rates to customers where negative rates affect to a larger extent lending rates than deposit rates.

Table 6. Explanatory determinants of net interest margins (NIM)

Determinant	*Effect*
Size	-
Size²	+
Liquidity	-
Efficiency	-
Asset quality	+
Total equity to total assets	+
Loan growth	-
Reserves at central banks	+
Bank taxation	-
GDP growth	-
Inflation	-
Domestic credit to GDP	-
Credit info	-
Legal rights	+



Note: In blue those statistically significant at least at 10%.
Source: Authors' own elaboration.

[8] Molyneaux, Reghezza and Xie (2019) find that countries where central banks implemented negative interest rates experienced a decline in net interest margins of 16.41% compared to countries that did not adopt negative interest rates.

4.5. The role of bank capitalisation and liquidity on bank margins under negative interest rates

We also examine whether the impact of negative interest rates could be different depending on the level of capitalization. Preliminary evidence shows that in a low interest environment the ex-ante level of solvency may play a role in the evolution of interest margins. Molyneaux, Reghezza and Xie (2019) argue that banks holding excessive capital above the regulatory requirements face larger opportunity costs and downside pressure on profitability. We split the sample above and below the median value of the Tier 1 ratio and re-run the baseline equations for the two sub-samples. Columns 3 and 4 in Table 7 show that high-capitalized banks under a negative interest rate scenario experience larger declines in their interest margins. This result is in line with Molyneaux, Reghezza and Xie (2019).

Table 7. Regressions by level of liquidity, capitalisation, and reserves at central banks

	NIM		*NIM*		*NIM*	
Variables	*High-liquidity banks*	*Less-liquidity banks*	*High-capitalised banks*	*Less-capitalised banks*	*High reserves central banks*	*Less reserves central banks*
Negative int. rate	-0.341**	-0.0193	-0.352**	0.253	-0.262**	0.0466
(DID term)	(0.136)	(0.252)	(0.142)	(0.204)	(0.152)	(0.0988)
Size	-1.24e-09**	-7.85e-10**	-5.34e-10	-2.86e-09***	-5.01e-10	-1.91e-09***
	(6.30e-10)	(3.23e-10)	(4.78e-10)	(9.06e-10)	(5.13e-10)	(5.43e-10)
$Size^2$	5.96e-19*	3.61e-19**	2.68e-19	2.60e-18***	2.56e-19	6.06e-19***
	(3.53e-19)	(1.52e-19)	(2.19e-19)	(8.62e-19)	(2.46e-19)	(2.23e-19)
Liquidity	-0.0289***	-0.0126***	-0.0271***	-0.00276	-0.0366***	-0.00982***
	(0.00382)	(0.00427)	(0.00474)	(0.00494)	(0.00483)	(0.00258)
Efficiency	-0.00324**	-0.00325**	-0.00264*	-0.00444***	-0.00420***	-0.00240**
	(0.00126)	(0.00165)	(0.00150)	(0.00172)	(0.00144)	(0.000947)
Asset quality	0.00594	0.00619	0.00770	0.00692**	0.00900*	0.00673*
	(0.00548)	(0.00423)	(0.00698)	(0.00350)	(0.00543)	(0.00401)
Total equity to total assets	0.0707***	0.148***	0.0827***	0.0827***	0.0961***	0.0358***
	(0.0134)	(0.0252)	(0.0168)	(0.0142)	(0.0212)	(0.00819)
Loan growth	-0.00328**	-0.00232*	-0.00476***	-4.53e-05	-0.00494***	0.000218
	(0.00144)	(0.00132)	(0.00145)	(0.00203)	(0.00160)	(0.00105)
Reserves at central banks	0.0980***	0.0468***	0.102***	0.0476***	0.107***	0.371***
	(0.0242)	(0.0109)	(0.0221)	(0.0109)	(0.0237)	(0.0802)
Bank taxation	-0.00632	0.00267	-0.00491	0.00137	0.000409	-0.00183
	(0.00591)	(0.00283)	(0.00635)	(0.00347)	(0.00450)	(0.00354)
GDP growth	0.00438	-0.0440	-0.0681*	0.0657	0.00440	-0.0637**
	(0.0385)	(0.0751)	(0.0408)	(0.0437)	(0.0336)	(0.0283)
Inflation	0.0162	-0.0373	-0.0121	0.00731	-0.00951	0.107**
	(0.0222)	(0.0360)	(0.0301)	(0.0388)	(0.0125)	(0.0418)
Domestic credit to GDP	-0.00529	-0.0119***	-0.00549	-0.0132**	-0.00703	-0.00902*
	(0.00744)	(0.00361)	(0.00548)	(0.00557)	(0.00527)	(0.00475)
Credit info	-1.270	0.135	-0.195	-0.465	-0.635	2.478*
	(0.945)	(0.831)	(0.866)	(0.874)	(0.708)	(1.426)
Legal rights	4.145***	0.908	3.363***	-1.832	2.872***	1.734
	(0.978)	(0.855)	(0.675)	(2.482)	(0.756)	(1.780)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,989	6,620	4,650	8,959	6,805	6,804
R-squared	0.562	0.535	0.545	0.497	0.537	0.430

Note: *, ** and *** denote statistically significant at 10, 5 and 1 per cent, respectively.
Source: Authors' own elaboration.

We also examine whether banks with more liquid assets are more affected by negative interest rates. We split the sample by the median value of the ratio of liquid assets to total assets and then re-run the baseline regressions for the two sub-samples. Columns 1 and 2 of Table 7 show that banks with more liquid assets operating under negative interest rates were particularly more affected than banks with more liquid assets under positive official interest rates environments.

Additionally, we examine whether banks with more reserves at central banks are more affected by negative interest rates. We split the sample according to the median level of the ratio of cash and balances with central banks and re-run the regressions for the two sub-samples. Table 7 also shows that banks with larger reserves at central banks have experienced a larger decrease in their interest margins that the banks with large reserves at central banks that did not apply NIRP.

4.6. Are high-deposit banks more affected by negative interest rates?

Some studies argue that negative interest rates have a differential effect on margins depending on the funding structure of the bank. Banks with a larger deposits base could face a larger negative impact if, as suggested in Figure 2, they are not able to pass rate decreases to customer deposit rates. We split the sample according to the median value of the ratio of customer deposits to total funding (excluding derivatives) and re-run the regression for the two sub-samples. Table 8 shows that interest margins of banks with more customer deposits as a percentage of total funding are significantly more negatively affected by NIRP than the interest margins of banks with large deposit bases in countries with positive interest rate policies.

Table 8. Regressions on interest expenses by level of customer deposits

	Interest Expenses	
Variables	*High-deposits Banks*	*Low-deposits Banks*
Negative int. rate (DID term)	-0.0883	-0.513***
	(0.0789)	(0.0940)
Size	-2.64e-09	1.51e-10
	(3.68e-09)	(3.50e-10)
Size^2	6.77e-18	-1.39e-19
	(1.21e-17)	(1.64e-19)
Liquidity	-0.0167***	-0.0174***
	(0.00224)	(0.00343)
Efficiency	-0.000452	-0.000212
	(0.00101)	(0.000703)
Asset quality	-0.00412	0.000226
	(0.00301)	(0.00439)
Total equity to total assets	-0.0184***	-0.00556
	(0.00616)	(0.00665)
Loan growth	0.00261**	0.00138**
	(0.00107)	(0.000689)
Reserves at central banks	-0.00880	0.00357
	(0.00557)	(0.00611)
Bank taxation	-0.0106**	0.00151
	(0.00423)	(0.00577)
GDP growth	-0.0519*	-0.0510**
	(0.0313)	(0.0226)
Inflation	0.0924***	0.0427**
	(0.0286)	(0.0167)
Domestic credit to GDP	0.00522	-0.00299
	(0.00338)	(0.00579)
Credit info	1.824**	3.795***
	(0.759)	(1.105)
Legal rights	1.762**	2.866***
	(0.697)	(0.559)
Year fixed effects	Yes	Yes
Country fixed effects	Yes	Yes
Observations	5,591	7,993
R-squared	0.721	0.674

Note: *, ** and *** denote statistically significant at 10, 5 and 1 per cent, respectively.
Source: Authors' own elaboration.

4.7. Robustness checks

4.7.1. Sub-samples

While we have assumed that all countries have experienced similar macroeconomic and institutional environments, it could be the case that some non-core European countries may have been subjected to specific economic and institutional features that potentially introduce a bias in our results. For robustness purposes, we re-run our tests for the core and large European economies, whose economic cycles are synchronized and whose banking systems are relatively quite similar. Hence, we restrict our sample to Belgium, France, Germany, Italy, Netherlands, Poland, United Kingdom and Spain. Panel A of Table 9 shows that the results remain qualitatively similar to those of the total sample.

Table 9. Robustness checks

	Panel A. Core European countries		
Variables	*Net Interest Margin (NIM)*	*Interest Income*	*Interest Expenses*
Negative Int. Rate (DID term)	-0.264**	-0.484***	-0.227**
	(0.108)	(0.164)	(0.096)
Year fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Observations	9,202	9,202	12,539
R-squared	0.1935	0.2088	0.3052
	Panel B. Exclusion of Eurasian economies		
Variables	*Net Interest Margin (NIM)*	*Interest Income*	*Interest Expenses*
Negative Int. Rate (DID term)	-0.190***	-0.634***	-0.488***
	(0.081)	(0.120)	(0.048)
Year fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Observations	12,551	12,549	12,539
R-squared	0.3110	0.3650	0.4126
	Panel C. Exclusion of later adopters		
Variables	*Net Interest Margin (NIM)*	*Interest Income*	*Interest Expenses*
Negative Int. Rate (DID term)	-0.605***	-0.967***	-0.276**
	(0.196)	(0.247)	(0.105)
Year fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Observations	12,352	12,352	12,330
R-squared	0.5537	0.7120	0.6887
	Panel D. Exclusion of German banks		
Variables	*Net Interest Margin (NIM)*	*Interest Income*	*Interest Expenses*
Negative Int. Rate (DID term)	-0.278**	-0.557***	-0.327**
	(0.116)	(0.141)	(0.063)
Year fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Observations	7,951	7,949	7,931
R-squared	0.5395	0.7071	0.6828
	Panel E. Placebo: Random adoption of negative interest rate policies		
Variables	*Net Interest Margin (NIM)*	*Interest Income*	*Interest Expenses*
Negative Int. Rate (DID term)	-0.168	-0.026	0.229
	(0.136)	(0.186)	(0.118)
Year fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Observations	13,609	13,607	13,584
R-squared	0.5292	0.6937	0.6819
	Panel F. Bank fixed effects		
Variables	*Net Interest Margin (NIM)*	*Interest Income*	*Interest Expenses*
Negative Int. Rate (DID term)	-0.169**	-0.735***	-0.416***
	(0.074)	(0.084)	(0.052)
Bank fixed effects	Yes	Yes	Yes
Observations	13,609	13,607	13,584
R-squared	0.906	0.929	0.902

Note: *, ** and *** denote statistically significant at 10, 5 and 1 per cent, respectively.
Source: Authors' own elaboration.

Furthermore, we also exclude those banks which are not operating in continental Europe (Turkey, Belarus, Ukraine, and Russia) since they are more likely to be influenced by the Euroasian macroeconomic environment. The results are shown in Panel B of Table 9 and reveal no material difference with the baseline findings.

4.7.2. Later adopters

Since Switzerland, Bulgaria, Norway and Sweden adopted the negative interest rates policies later in 2015, we exclude these later adopters from our sample to check if the findings are still valid. Panel C of Table 9, show that the exclusion of these later adopters do not significantly alter our baseline results.

4.7.3. German banks

The German banking system is the largest in Europe by number of banks.[9] Naturally, most of the banks in the sample are German banks. However, excluding them from the sample (Panel D of Table 9) does not significantly change our results.

4.7.4. Placebo test: Random adoption of negative interest rates policies

We conduct an alternative placebo experiment for further robustness. In particular, we randomly categorize countries as adopter or non-adopters of negative interest rate policies, and then the model is re-run. In Panel E of Table 9, we show that the DID coefficients are statistically insignificant, suggesting that our results are not driven by alternative forces beyond country classification.

4.7.5. Unobserved bank-specific characteristics

Finally, it might be that some unobserved bank-specific characteristics (*e.g.,* banks' differential ability to charge customers for deposits) could explain our main results. In order to ensure that the main results do not hinge upon the omission of variables, we also check robustness using specifications with bank fixed effects. Panel F of Table 9 shows that, after accounting for bank fixed effects in our regressions, our main results remain robust.

5. CONCLUSIONS

The aim of this paper is two-fold. First of all, it surveys the international experience of negative interest rates and the existing theoretical and empirical research of the impact on banks and the financial system as a whole. Secondly, it investigates the impact of negative interest rates on the European banking sector using a dataset of 3,155 banks from 36 European countries over 2011–2018.

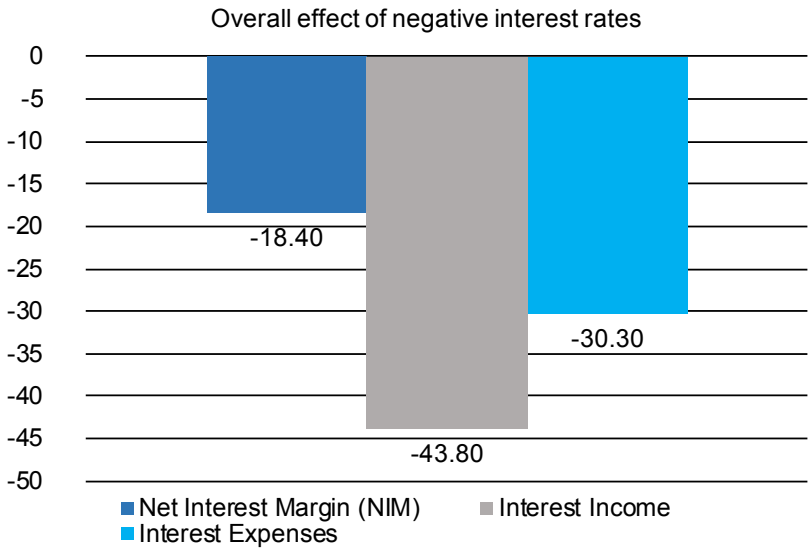
We illustrate how the discussion on negative official interest rates is part of the most general debate on the need to rethink macroeconomic policies. Although setting negative rates could be seem as a part of a continuum in central bank rate policy, the limits seems to be both practical (*e.g.,* reluctance of commercial banks to pass negative rates to depositors, disruption in financial markets, hoarding of cash in the private sector) and of a political nature (*e.g.,* limits to the quasi-fiscal powers of central banks).

The survey of the international experience and of previous empirical analyses on the impact of negative rates on bank profitability reveals there are multifacet effects. On the one hand, there is a negative impact on the interest rate structure (relationship between the official rate and the yield curve) that also have a detrimental effect on bank net interest income. On the other hand, there is a positive impact of short-

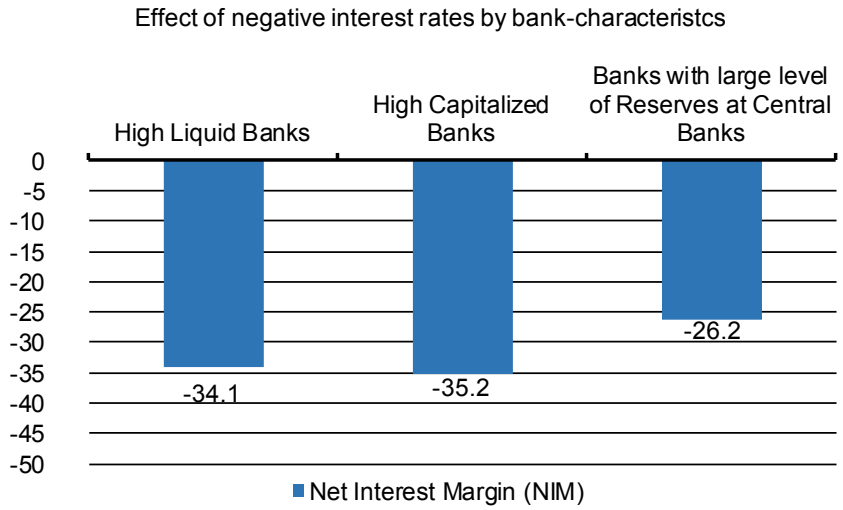
[9] http://sdw.ecb.europa.eu/

Table 10. Summary of the main empirical findings

Overall effect of negative interest rates (% change)



Effect of negative interest rates by bank-characteristics (% change)



Effect of negative interest rates by level of customer deposits (% change)

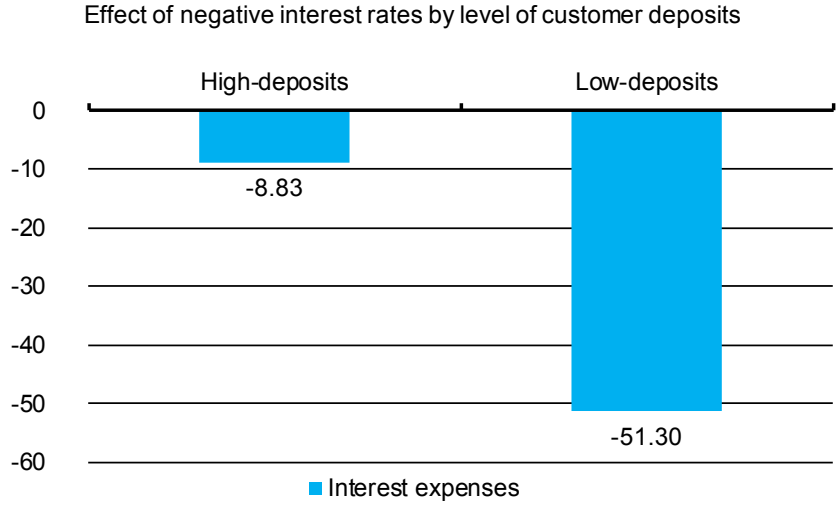
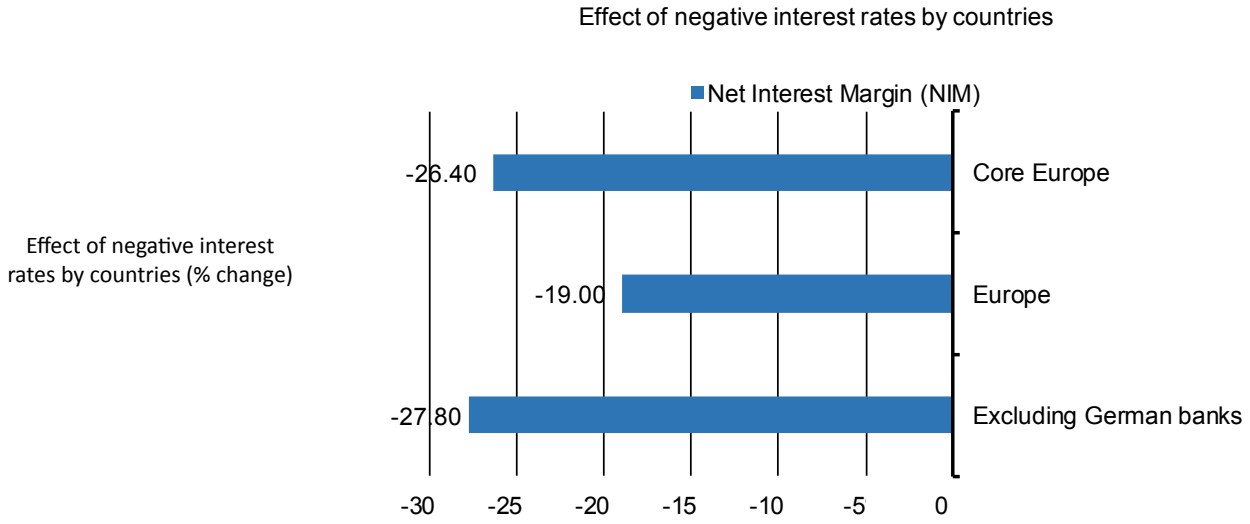


Table 10. Summary of the main empirical findings (*continued*)



Source: Authors' own elaboration.

term rates on loan loss provisions and asset impairment as it implies a higher debt service for debtors. Empirically, the first effect seems to dominate over the second so that rates below zero represent a net negative externality for banks. In this paper, we also show that there are several other negative effects documented beyond the banking sector, including anomalies and distortions in liquidity markets, asset pricing and in real estate.

Overall, the paper has identified a number of adverse effects of negative interest rates that should be considered as well as the potential benefits of such as unconventional monetary policies. These findings argue in favor of considering whether the negative consequences of low interest rates may outweigh the benefits. The duration of the unconventional environment seems very relevant in this analysis. While unconventional monetary policies were supposed to be temporary, the central banks that adopted do not seem to have achieved the goals they intended and they have gone even further (more quantitative easing and/or even lower rates).

Regarding our empirical investigation on the impact of negative interest rate policies (NIRP) on European banks, we use a difference-in-differences methodology, and show that banks in negative interest-rate environments experienced a 18.4% decrease in their net interest margins compared to other banks operating in European countries that did not adopt negative interest rates. We also show that banks holding more liquid assets, high-capitalized and maintaining more reserves at central banks have experienced a larger decrease in their interest margins under the negative interest rate environment. Importantly, banks taking more customer deposits are also found to be more affected by low or negative official rates. Our results are consistent to a number of sample, specifications and econometric robustness checks.

Overall, this study may contribute to the current debate on the effectiveness of unconventional monetary policy and on the need of revising the side effects of keeping interest rates low or negative for a prolonged time period. It is not just that they are detrimental for commercial banks, there is also a growing concern that the overall effects in the economy may become negative if rates remain too low for too long. Tracking the impact of unconventional monetary policies in different sides of the financial system seems urgent. Moreover, this monitoring analysis should be also prospective, and consider how changes in pricing and incentives related to low or negative rates may generate financial instability in the near future. Corporate

debt sustainability, sovereign to private debt contagion, rise of shadow banking, liquidity hoarding, or distortions in real estate markets should be considered as candidates. Achieving basic funding and investment functions in the financial sector should be incentive-compatible and protracted low interest rates may not be helpful in this front.

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Appendix. Selected studies on the effects of negative rates on banks

Reference	*Geographic scope*	*Time period*	*Type of analysis*	*Results*
Arce, García Posada and Mayordomo (2019)	Eurozone	2014Q2 - 2017Q3	Empirical	Banks that report a higher impact of negative interest rates on their income tend to exhibit a lower risk tolerance and to grant loans with shorter maturity and lower average loan size. Negative rates do not necessarily contract the supply of credit and that the so-called "reversal rate" may not have been reached yet.
Lopez, Rose and Spiegel (2018)	27 countries	2010 - 2016	Empirical	Negative interest rates lead banks to experience statistically significant losses both on lending income and "other" interest income. Banks that rely relatively more on deposits are more vulnerable to losses attributable to a zero-lower bound on deposits than their counterpart.
Molyneaux, Reghezza, Thornton, and Xie (2019)	33 OECD countries	2012 - 2016	Empirical	Following the introduction of negative interest rates, bank lending was weaker in those countries that adopted negative interest rates. This adverse effect of negative interest rates appears to have been stronger for banks that were smaller, more dependent on retail deposit funding, less well capitalized, had business models reliant on interest income, and operated in more competitive markets.
Molyneaux, Reghezza, and Xie (2019)	33 OECD countries	2012 - 2016	Empirical	Bank margins and profits fell in NIRP- adopter countries compared to countries that did not adopt the policy. The NIRP effect depends on bank specific-characteristics such as size, funding structure, business models, assets repricing and product –line specialization.
Eggertsson, Juelsrud and Wold (2017)	6 countries (Sweden, Denmark, Switzerland, Japan, Euro area, and Germany)	2008 - 2017	Empirical	There has been a collapse in pass-through to deposit and lending rates once the policy rate turns negative. Credit growth in the post-zero environment is lower for banks which rely heavily on deposit financing.
Heide, Saidi and Schepens (2017)	Euro Area	2013 - 2015	Empirical	Negative interest rates induces banks with more deposits to lend less and to riskier borrowers.
Ampudia *et al.* (2018)	Euro Area	1999 - 2016Q2	Empirical	In a period of low and even negative interest rates, further interest rate cuts became detrimental for banks' equity values.
Basten and Mariathasan (2018)	Switzerland	July 2013 - June 2016	Empirical	Banks affected by negative interest rates banks moved liquidity away from costly central bank accounts and towards the interbank market as well as towards riskier asset classes, such as uncollateralized loans, mortgages and financial assets.
Nucera *et al.* (2017)	Euro Area	2011 - 2016	Empirical	The risk impact of negative rates depends on banks' business models: Large banks with diversified income streams are perceived as less risky, while smaller and more traditional banks are perceived as more risky.
Urbschat (2018)	Germany	2003 - 2016	Empirical	While negative interest rate policies may benefit some banks in the short run via for instance reduced refinancing costs or lower loan loss provisions, many banks with high deposit ratios face lower net interest income and lower credit growth rates.
Banerjee and Hofmann (2018)	14 advanced economies	1980 - 2017	Empirical	Lower nominal interest rates predict an increase in the percentage of zombie firms, while the effect of bank health is less clear-cut.
Demiralp, Eisenschmidt and Vlassopoulos (2017)	Euro Area	July 2014 - 2016	Empirical	They find evidence of a significant adjustment of banks' balance sheets during the negative interest rate period. Banks tend to extend more loans, hold more non-domestic government bonds and rely less on wholesale funding.

Source: Authors' own elaboration.


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