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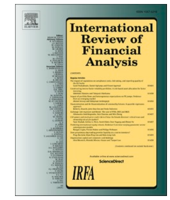

Impacts of sovereign risk premium on bank profitability: Evidence from euro area

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ABSTRACT

We analyse the effects of low and negative interest rates and sovereign risk premium on bank profitability among 154 Eurozone banks during the period 2005–2019. In contrast to some of the results in the previous literature, we find that the euro area banks have not suffered too much from the extremely low and negative interest rate era regarding their net interest margins. However, the overall profitability has lowered clearly during the sample period, and the sovereign risk premium has a robust negative effect on all the overall profitability measures, both with risk-adjustment and without it, but it seems to have an increasing effect on the degree of wholesale funding and loan loss provisions. Hence, the profitability puzzle can be explained by a shift towards low-cost wholesale-based funding. Banks have also exercised more loan loss provisions because of the increment in overall risk of the economy. However, if the negative interest rate era still prevails for long, the banking sector faces serious problems based on our results.

1. Introduction

Based on the principal idea of borrowing short and lending long, standard banking theory advocates a lowering effect of generally decreasing market interest rates on bank profitability. After the Global Financial Crisis (GFC) and the Eurozone Sovereign Debt Crisis (ESDC), the European Central Bank (ECB) has been pursuing an unconventionally low interest rate approach to save the economy from the deflation trap and to boost the real economic activity. The original aim has been to stimulate banks to lend out funding to their borrower customers instead of hoarding cash in the form of reserve balances at the central bank, thereby allocating funding to the productive uses and stimulating the aggregate demand of the economy. Hence, the low (and ultimately even negative) nominal interest rate is deemed to have a specific connection with the profitability of the banking sector.

For example, Jobst and Lin (2016) have stated that the low interest rate has been an obstacle that contracts banks' returns. In the same fashion, Borio, Gambacorta, and Hofmann (2017) found that bank profitability declines in accordance with the low interest rate. More specifically, Borio and Gambacorta (2017) have claimed that as the interest rate moves towards the zero level, the expansion of lending dwindles, indicating that the expansive monetary policy's transmission mechanism becomes less effective as the interest rate approaches zero.[2] This problem seems to have been in connection to a well-known phenomenon, the so-called "zero-lower bound" (ZLB) effect, suggesting that the nominal interest rate could not pass the zero level. However, for over seven years now, in many European countries this has no longer been the case as the central banks have started to reach out to the negative interest rate policy in the hope of lowering the nominal interest rates even further. As a result, in some cases also the private customers have been charged a fee for keeping extensive amounts of their cash holdings at bank accounts, which is an unprecedented event. This makes the linkage

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[2] However, in a very recent study Altavilla, Boucinha, Holton, and Ongena (2021) stress the fact that for the part of extension or contraction of bank lending activities due to the unconventional monetary policy actions, it is vital to analyse both the demand and supply sides of the bank loan markets. Based on a novel bank-specific survey data matched with balance sheet information for euro area banks, they find that after a monetary policy shock, bank strength influences credit demand as well as credit supply. They also find that it is vital to control for bank-specific loan demand when identifying the credit supply shocks at the aggregate level. According to their results it seems that even after fully controlling for the demand, borrower quality, and bank strength characteristics, the unconventional monetary policy actions do stimulate loan supply. However, their analysis does not extend to the profitability effects of negative interest rate period (NIRP), that is the focus of our study

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between the bank profitability and monetary policy stance in general, and unconventional monetary policy in particular, even more a topic of interest.

Despite being a relatively new phenomenon, this connection has already been scrutinized in some studies. Most of them have shown that the negative interest rate harms banks' net interest margin (NIM) (Altavilla, Boucinha, & Peydró, 2018; Basten & Mariathasan, 2018). The reason behind this is that banks are reluctant to transfer the negative rate to their customers (Basten & Mariathasan, 2018; Bech & Malkhozov, 2016). However, the negative margin is partly compensated by shifts in the bank business models (i.e., from retail-based funding to wholesale-based funding, and from traditional to more operationally diversified banks). This has resulted to a situation where already in mid-August 2019, Bloomberg stated in their report "Depositors are Next as Nordic Banks Buckle under Negative Rates", that banks have been in this stage long enough to survive the regime. They have moved towards other services that generate fee and paid more attention to especially their (short-term) asset management. However, in the Bloomberg report it was also emphasized that those changes would not be enough if the negative rate environment does not cease in the near future.

In addition to the experienced period of extremely low and even negative interest rates at the money market maturities, we have now also witnessed a period of very low and even negative values also for the government bond yields[3] in the euro area for more than five years. This is obviously in connection to the extensive asset purchase programs introduced by the ECB, that have strongly involved also the purchase of government assets especially after the ESDC since 2012. One of the key reasons for the strong involvement of central banks in sovereign debt markets has been to lower the *sovereign risk premium*, in order to prevent the dramatic increases in the funding costs of the public sector debt during the painfully slow recovery of the real economy after already the GFC.

Based on these empirical facts, this study attempts to answer two primary research questions related to the negative interest rate regime. First, we will analyse if the low and negative interest rates, and more specifically, the *sovereign risk premium*, have had specific impacts on the profitability of banks. For this purpose, the sovereign risk premium is defined in this study in a novel way as the *difference between the long-term government bond yield and the shadow interest rate*. For this partial question it is also necessary to examine whether this effect (if there is any) is heterogeneous depending on the sort of profitability indicator deployed, i.e., the standard, non-risk adjusted versus risk-weighted profitability indicators. Second, we will focus on the question of whether there are any differences with respect to this effect in disparate banking groups, i.e., 'significant' banks versus 'less significant' banks based on the definition given by the ECB, and the GIIPS banks versus non-GIIPS banks. Hence, this study contributes to many strands in the banking literature, but most strongly to the profitability analysis of the banking sector during the unconventional monetary policy era and the application of the shadow rate in lieu of the monetary policy stance.

More specifically, we extend the previous work in two novel dimensions. First, we employ a new measure for the sovereign risk premium, defined as the spread between the government bond yields of countries in the Eurozone and the ECB shadow interest rate supposed to reflect the 'effective' monetary policy steering rate especially during the negative interest rate era. In contrast to our approach, many previous studies have used the slope of the yield curve, based on the difference between the long-term bond yield and interbank market rate to measure the sovereign risk premium. However, to the best of our knowledge, none of the previous studies has utilized the shadow rate to examine the bank profitability in this way. The main reason for utilizing the shadow rate is that in previous studies (see section 2.2.3) it has been shown to be a highly effective measure for the monetary policy steering rate when the actual policy rates hover near or go below zero. As we shall show in the data section 3, the euro area shadow rate as a general, wide reflector of so called effective monetary policy interest rate has moved more or less in tandem with the Euro Overnight Index Average (EONIA), but when the EONIA gets stuck at the zero level and goes only mildly negative, the shadow rate enters the negative zone much more aggressively. Additionally, the sovereign risk premium involves the use of country-level bond yield, which in our evaluation reflects the sovereign risks anticipated by the market participants in the post-GFC and ESDC, commencing in 2011. Second, regarding the effects on bank profitability, we take into account that the effects of sovereign risk premium might be very different to the risk-adjusted profitability compared to the 'standard', non-risk adjusted measures.

Our baseline results can be summarized as follows. First, the sovereign risk premium has a negative impact on both the non-risk-adjusted and risk-adjusted profitability indicators, but with a varying degree. To be more specific, a rise of 1 percentage point in the sovereign risk premium induces a drop of 0.22 percentage points in banks' return on average assets. This impact is clearly higher in the case of return on average equity. There is no significant difference between the results for the standard and risk-weighted profitability indicators. In practise, based on our definition of the sovereign risk premium, an increase in it means that either the government bond yield rises, or the shadow rate declines, or both take place simultaneously. Nevertheless, our main results implicitly indicate that banks suffer losses in overall profitability as the unconventionally expansive monetary policy shocks take place in the economy. This is consistent with some earlier studies (Borio et al., 2017; Molyneux, Reghezza, & Xie, 2018), but none of these previous studies have focused on using the shadow rate data in the analyses.

Furthermore, contrary to some of the previous literature, our results indicate that the NIM of Eurozone banks has improved when the sovereign risk premium has increased or, to put it differently, for example when the shadow rate has moved deeper into the negative territory rate without a simultaneous change in the government bond yield. This has created a puzzle; while NIM, a contributor to all the other profitability indicators (i.e., ROAA, ROAE, and RORWA), has improved, these other profitability indicators have decreased. There are two potential explanations for this confusing result. First, as the shadow rate goes down, the interbank interest rates usually decrease as well. Hence, during the negative interest rate era, when a bank obtains new funding from the market with a negative interest rate, the NIM improves because the overall cost burden of the bank's funding portfolio lowers, even if it gets more funding (i.e., the amount of its borrowed loans increases). Second, after the GFC and GR, the overall risk of the economy has increased and the banks have started to weigh more risk on their loans and put aside more loan loss provisions, which squeezes other overall profitability indicators than the NIM. Our comprehensive additional analyses show that indeed, both the wholesale funding and loan loss provisions have reacted to the sovereign risk premium in the low and negative rate period in this spirit with statistically significant reactions.

Finally, the profitability of less significant banks seems to have been affected more heavily by the sovereign risk premium during the low and negative rate era. In contrast, significant banks have experienced an enormous change in their asset profitability compared to the less significant banks. These facts might be attributable to more significant banks downsizing their deposits more aggressively. Meanwhile, banks from GIIPS countries seem to have benefitted from the strongly easing monetary policy. In particular, during the financial crisis, the effect of the sovereign risk premium, which was primarily driven by the ESDC, on the return on assets of GIIPS banks is massive, but it has been mitigated after the implementation of the low and negative rates since 2012. The impact of the sovereign risk premium on the asset profitability of non-

[3] For example, in our data sample the German 10-year government bond yield has been below 0.5% per annum since 2015 and in 2019 its annual mean value used in our empirical analyses was −0.254%. More details on the exact central bank interventions in the sovereign debt markets since GFC are given in section 2.2.4.

GIIPS banks is more significant than for the GIIPS banks after 2012. Notwithstanding that, there is no support indicating that this impact is strengthened or weakened compared to the period before 2012.

Obviously, if the negative interest rates period (NIRP) continues too long, the Euro banking sector might face an even worse situation in the profitability development owning to the effects of negative interest rates on overall profitability measures. Hence, one of our main policy suggestions is, that at least for the sake of longer-term bank profitability, the ECB should actually start to gradually withdraw its strong asset purchase programs, and let especially the short-term interest rates start to gradually rise towards even positive side, and in the circumstances of positive yield curve slopes (as has been witnessed also throughout the negative interest rate period), the long-term interest rate would start to gradually rise, too, and the markets would be aiming towards a more normal situation, assuming that the ECB would not intervene as heavily in the longer maturity asset markets in the future. The main thing in this process is, that as long as the short-term rates increase more than the long-term bond market yields, the sovereign risk premium decreases, and according to our results, it has a positive effect on the bank profitability, too. Now that the inflation pressures are clearly emerging also in the euro area, partly due to the strong and fast recovery of the real economy after the COVID-19 crisis, this should actually be the natural path to be followed in the near future.

This study is organized as follows. In the next section, prior studies related to the topic will be discussed. Section 3 describes in more details the data and empirical methodology, whereas section 4 presents the empirical results and discusses the most essential findings from the empirical analysis. Finally, section 5 summarizes the conclusions, gives some policy recommendations, and discusses prominent extensions for further research in the future.

2. Background and literature review

2.1. Background

According to the standard text-book and practical thinking of monetary economics, (nominal/real) interest rate is the price of (nominal/ real) money holdings. Skipping the effects of inflation for now, for instance, as a depositor deposits his/ her money in a commercial bank, he/she may withdraw both the nominal principal and interest at the time of maturity. The interest rate here is regarded as the expense or cost that the bank owes to the depositor to obtain the funding. Theoretically, it has been long argued that the nominal interest rates cannot turn negative. Already according to Fisher (1930), if a commodity could be stored free of cost over time, the interest rate in units of that commodity never falls below zero. Likewise, as long as cash is stored without costs, the interest rates will not become negative. In the standard banking and monetary economics literature, this fact has been labelled as the ZLB bound, which states that when the short-term interest rates are at or near zero, central banks cannot lower such rates any further to boost up lending and borrowing demand (Eggertsson & Woodford, 2003; Keynes, 1936; Krugman, 1998).

This bound has turned to be a problem in the most recent, real-life behaviour of some economies and markets during and after the Global Financial Crisis and the following Great Recession (GR) (2007–2013). Central banks of several countries have actively been trying to bolster the economy via conventional and unconventional expansive monetary policy actions. The need for also unconventional actions is based on the fact, that when an economy suffers from a full-scale financial crisis, the conventional monetary policy fails to perform efficiently (Potter, 2019). The first reason is that the financial system is unsuccessful in allocating capital to productive uses (Mishkin, 2016). Specifically, in the 2007–2009 financial crisis, banks began to hoard cash despite massive injections of liquidity into the financial system and were unwilling to lend to each other. Furthermore, according to Berrospide (2013), bank liquidity hoarding is not a new phenomenon. For example, in the aftermath of the Great Depression, and particularly during the late 1930s, U.S. commercial banks accumulated substantial amounts of voluntary excess reserves. Already before this, Ramos (1996) justified that after a financial crisis, the banks often voluntarily hold excessive reserves to build buffers against future drains of cash. This is also considered as a message to the depositors that the bank is not insolvent and bank runs are not justifiable. The second reason is more directly related to the zero lower bound problem. To get rid of the deflationary trap, central banks have started to consider another approach, the *unconventional monetary policy*, in the hope of spurring levels of borrowing and spending (Mishkin, 2016).

Negative rates have been one characteristic of the non-conventional monetary policy tools. The goal has been to stimulate banks to lend out their funds instead of building up reserves at central banks. In July 2009, the Riksbank, the central bank of Sweden, was the first to introduce the negative nominal interest rates. It lowered the deposit rate, which is the rate for commercial banks to be received when they deposit their reserves at the central bank, to the level of −0.25%. Subsequently, the primary policy rate (repo rate) was lowered to −0.10%, and after this, the money market interest rates entered the negative zone, too. This level was maintained by active operations until January 2019.[4] After the first steps by the Riksbank, Central bank of Denmark and after this, the ECB were the next to follow, lowering one of its key interest rates to −0.1% in June 2014. Since the ECB had no familiarity with negative interest rates previously, it continued slowly over time, dropping the deposit facility rate in 10-basis-point intervals until it reached −0.5% in September 2019. Later, Switzerland and Japan also adopted negative policy rates in 2015 and 2016, respectively.

Theoretically, a negative policy rate applied by the central banks will be transmitted to the financial system via the deposit and lending rates. However, during the negative interest rate era, the fundamental principle of the interest rate as reflecting the price of nominal money holdings is reversed. In other words, depositors will be charged for putting their money at banks, while borrowers would be paid for taking on loans. The expected effects of this situation are that consumers and corporations would consume and invest more. Similarly, banks are expected to lend more to the general public instead of hoarding cash and holding it at central banks (Coeuré, 2016), so the central banks would attain their purposes to stimulate the economic situation.

Furthermore, domestic negative rates will make the investment climate less attractive to foreign investors. Consequently, the demand for domestic currency weakens, which improves the competitiveness of domestically produced commodities in the international markets. For example, in 2015, after the ECB started even more seriously the quantitative easing program, the Swiss National Bank cut the interest rate down to −0.75%. This slash in rate was to depreciate the Swiss Franc, supporting the exporters (Coppola, 2019).

Although the quotation of negative interest rates might be a solution in the context of the deflationary trap, it conveys some controversial concerns itself, too. The first concern is that it would motivate depositors to withdraw money from commercial banks (Haksar & Kopp, 2020). There is no incentive for the traditional banks to keep deposits at central banks either. Instead, they would choose to convert their reserves to currency, which possibly causes the financial system to constrain. The second concern is that negative interest rates would strongly impact the functionality of traditional banks (Chen, Katagiri, Surti, & Raddatz, 2018; Demiralp, Eisenschmidt, & Vlassopoulos, 2017). Banks make profits by selling liabilities with a particular combination of liquidity, risk, size and return and using the proceeds to buy assets with a different combination of liquidity, risk, size, and return (denoted as asset transformation, see e.g., Mishkin, 2016). Hence, the main source of bank profitability is the spread between the returns and costs from these

[4] Just before the starting of the COVID-19 crisis, Sweden was actually also the first country trying to get out of the negative interest rate territory.

activities. Apparently, this spread will be squeezed if interest rates turn negative, especially for those banks who could not pass the negative interest rates on their depositors for the fear that they would withdraw their deposits (Arseneau, 2020; Jobst & Lin, 2016). Eventually, banks will have to restrict their lending activities, reconstruct their portfolios, and tolerate more risks (Bottero et al., 2019; Brunnermeier & Koby, 2016; Heider, Saidi, & Schepens, 2019; Xu, Hu, & Das, 2019).

As stated in the introductory section, the impacts of low and negative interest rates on banks' profitability are here examined through utilizing a newly-defined form of sovereign risk premium measure. For this purpose, we claim that it is essential to understand how low and negative rates affect bank activities in the first place, and hence, what are the effects on profitability, too. We will next give more insights into how this mechanism has been scrutinized in the previous literature. After that, at the beginning of the data section, we will present the development of government bond yields and the shadow rate, which are the two constituents of the sovereign risk premium in this paper, during the unconventional policy era, mainly to demonstrate the pronounced ability of such constituents in capturing the monetary policy stance, macro-situation, and market anticipation. Finally, we will go through how other bank-level characteristics, which we deploy as the control variables in our empirical model, add to explain the development of bank profitability.

2.2. Literature review

2.2.1. Effect of policy rates on bank activities in general

Negative interest rates affect bank profitability first and foremost via changes in bank operations. Most of the previous research focuses on how banks' credit growth, portfolio risks, and asset compositions change during this special time. Borio and Gambacorta (2017) examined the responsiveness of 108 internationally significant banks to the low-interest-rate environment. They found that when the nominal interest rate level is low, the traditional monetary policy tools lose their effectiveness in stimulating banks' lending. This result holds even when they control for other relevant conditions such as business and financial cycles, and for the bank-level characteristics. Heider et al. (2019) studied the credit provided by 46 banks from the euro area to individual firms between 2013 and 2015. In their empirical analysis, they formed an interaction term that comprised of banks' deposit ratios and a dummy variable determining whether the examination period was after June 2014 (i.e., the point of time that the negative policy rate in the euro area took effect). Their results indicated that the deposit-funding-dependent banks have to cut lending and reallocate loans towards riskier firms during the negative rate period in order to maintain their profitability. Urbschat (2018) obtained similar results when studying the lending activity of a large sample of German banks between 2003 and 2017. Specifically, high deposit banks are likely to experience a decrease in credit growth under negative rates, due to which their net interest income and profitability are eroded. Furthermore, Altavilla, Burlon, Giannetti, and Holton (2019) noticed that the banks who could pass the negative rates onto lower deposit rates are able to increase their credit supply. In contrast, Klein (2020) stressed the importance to separate the low (but positive) and negative interest rates, because these distinct periods obviously contract (or stimulate) banks' lending in different ways. New lending is positively correlated with NIM, which implies that banks are less incentivized to issue new loans. However, this effect diminishes during negative interest rates, as banks want to compensate their income by granting new loans regardless of the average margin they earn.

Regarding the risk-taking level, there is quite a lot of evidence supporting the hypothesis that banks increase the riskiness of their portfolios after central banks implement negative interest rates. Delis and Kouretas (2011) found that banks tolerate more risks under the negative rates. Aramonte, Lee, and Stebunovs (2019) studied the $900 billion U.S syndicated loan market, and their results show that when the long-term or forward short-term rates decline due to the unconventional monetary policy actions, non-bank institutions take more risks in syndicated-loan investments. Meanwhile, the banks who originate such syndicated loan deals divest them shortly afterwards. Nucera, Lucas, Schaumburg, and Schwaab (2017) utilized a panel regression model, and they defined a new term, "SRisk", which represents banks' risk. It measures a bank's propensity to become undercapitalized in a crisis. They found that after the interest rates go below zero, not all, but at least many banks become riskier. In addition, the riskiness of a bank is dependent on its business model. Large banks with more diversified activities are perceived to be less risky. By contrast, traditional banks that depend heavily on deposit funding are considered riskier. Analogously, Bubeck, Maddaloni, and Peydró (2020), based on studying 26 large euro area banking groups, reported that banks that rely on deposit funding increase the portfolio riskiness in response to the movement of interest rates into the negative zone.

2.2.2. Effect of policy rates on bank profitability

Based on previous studies, banks have indeed responded to the implementation of negative policy rates differently by restricting lending or favouring more risky assets. All these movements contribute to the revision of bank profitability indicators. Since central banks have promulgated the negative rates, several scholars in the field have tried to measure in more details how banks' profits have been affected.

A significant number of studies support the claim that negative policy rates have a counter-impact on banks' profits based on compressing the NIM of banks. Bech and Malkhozov (2016) studied how four central banks in Europe executed the negative policy rates in practice. Their key finding in terms of policy transmission was that commercial banks are reluctant to pass the negative rates onto their retail-deposit rates, which obviously squeezes banks' net interest income margins. Bikker and Vervliet (2018) investigated the impact of the unusually low interest rate environment on the soundness of the U.S banking sector. Specifically, they examined profitability and risk-taking of such banks, using a dynamic panel data model which considers bank-specific and macroeconomic determinants, the market interest rate, and persistence effects. The results showed that bank profitability declines at low interest rate levels, which is caused by the reduction mainly in the NIM. However, the U.S. banks managed to keep the overall profitability unaffected by adjusting other margins and profitability determinants (e.g., by reducing loan loss provisions). At this point, it is obviously worth pointing out that *the U.S. banking system has still yet to face the experience of actually negative nominal interest rates*.

Regarding the most recent studies, Claessens, Coleman, and Donnelly (2018) deployed data on 3385 banks from 47 countries between 2005 and 2013. They found that the relationship between reference rates and NIM is non-linear. More specifically, when the reference rates drop by 1 percentage point, NIM will decrease by 8 basis points. Nevertheless, when the rates go lower further, this effect will become more significant, to a 20 basis points decrease in NIM. Hence, exceptionally low-interest rates do negatively affect bank profitability, but with significant variation. Analogously, Hanzlík and Teplý (2019) agreed that regardless of the type of the banks that were studied, their NIM experienced erosions under the low or even negative rates. Furthermore, this effect is positive concave, indicating that if market rates remain at an extremely low level, the downward effect might me more striking.

Junttila, Raatikainen, and Perttunen (2021) analysed the effects of changes in the EONIA rate on the set of four relevant profitability indicators of the Finnish group of cooperative banks, the OP Group. The data set comprises monthly observations from 01/2009 to 12/2018. One of the differences of their analysis compared to others is that besides non-risk-adjusted indicators (i.e., return on assets, ROA, return on equity, ROE, and net interest margins NIM), they also included the return on economic capital (ROEC) as a risk-adjusted profitability measure. This point is closely related to the analysis in this study, where another risk-adjusted measure - the return on risk-adjusted assets will be deployed. Their empirical results contradict some of those in earlier studies. The introduction of negative policy rates actually influenced positively many OP banks during the first three years of the quotation of negative money market interest rates in the euro area. However, this claim is strongly dependent on the indicator of bank profitability. Furthermore, the largest banks in the sample seemed to experience the most robust results, especially when the ROEC measure was used. After the authors controlled for the almost-zero volatility of the money market rates and net income margins, they found a positive connection between the changes in market interest rates and banks' NIM. It is also evident from their results that the ROEC starts to deteriorate in general terms since the beginning of 2017. Hence, it seems that in the most recent data, the banks especially in the group of biggest banks were no longer able to exploit the benefits from the wholesale-based funding with the negative interest rate for the loans taken from the central cooperative bank. In addition, the connection between profitability measures and other than net interest income components became very limited or even negative after 2017.

Molyneux et al. (2018) studied the impact of negative interest rate policy on bank profitability taking into account the bank-level and country-level effects, too. They deployed a bank-level database including 7352 banks from 33 OECD countries, using the difference-in-difference methodology. Their results show that the negative interest rate does put pressure on banks' profitability during the period from 2012 to 2016. Specifically, on average, a contraction of 16.41% in NIM and 3.06% in ROA was caused by the exceptional negative rates. Moreover, this effect was either amplified or weakened depending on the bank and country-level characteristics. The small banks are heavily dependent on interest income, specialize in real estate and mortgage, are well-capitalized, lend within borders, hedge weakly against interest rate risk, operate in a harsh competition environment, and where floating loan rates prevail, seem to undergo a more substantial adverse effect on profits and margins.

As discussed above, negative interest rates are prone to hurt bank profitability. However, many studies have found actually that there is no significant effect of low and negative rates on banks' overall profitability. Most of them justify that although suffering losses in NIM, banks are able to stabilize overall profitability by cutting off in funding costs or gains in non-interest income items. Detragiache, Tressel, and Turk-Ariss (2018) found that during the low policy rate period, the only region that witnessed a remarkable reduction in NIM is Eastern Europe. They argued that banks offset the lower lending rates with lower funding costs during the extremely low interest rates. Similar findings are reported for Denmark and Sweden, where the interest rates have remained low and negative for an extended period. However, bank margins have been still stable due to the compensation from non-interest income (Turk-Ariss, 2016). Basten and Mariathasan (2018) examined 68 Swiss banks, with the proportion of reserves acting as a proxy for the exposure to negative interest rates and found again that banks are reluctant to pass the negative rates onto deposit rates. Hence, they have to shorten the maturity composition of their balance sheet by reducing bond issuance, which results in more maturity mismatch. Banks who operate in more centralized markets increase their lending-related and overall fees to compensate for negative liability margins. Finally, Lopez, Rose, and Spiegel (2020) studied the effect of negative rates on bank profitability solely by exploiting the richness of the dataset instead of elaborating on econometric methods. More specifically, their dataset included observations of individual banks from 28 European countries and Japan. Their empirical results show that banks have experienced significant losses in net interest income related to lending and other interest income. Attempts to mitigate the interest expenses have not been sufficient enough to offset the losses. Large banks appear to have been more capable of adjusting the funding costs, unlike small banks. Importantly, significant gains in non-interest income seem to have been the main source when balancing the profitability.

Angori, Aristei, and Gallo (2019) studied the profitability of Eurozone banks during a 7-year period, commencing from 2008. They were explicitly concerned about NIM – a gauge of profitability sustainability, introducing the regulatory and institutional settings, too. Their results confirmed the negative impacts of extended negative low rates and flattening yield curve on bank profitability. By the way of comparison, the results suggested monetary policy should turn back to the normalization, based on considering the connection of money markets rates and yield curve slope to NIM as an inverted U-shape. In contrast to other literature affirming that non-interest income is a compensating source while NIM is compressed, Angori et al. (2019) found that an attempt to cross-sell will drive banks further away from their traditional lending activities.

Based on all these previous studies, the results on the impacts of extremely accommodative monetary policy featured by low and negative interest rates on profitability of banks are inconsistent and divergent. Hence, there is still room for further analysis.

2.2.3. *The shadow interest rate*

Several papers discussed in the previous parts have investigated the low and negative interest rates in view of either changes in central banks' reserves or interbank market rates, like for example the three-month interbank rates or Euribor (Hanzlík & Teplý, 2019; Junttila et al., 2021) and the yield curve (Borio et al., 2017; Claessens et al., 2018). The primary issue revolving around such market rates or yield curves is that these market rates only oscillate around the zero line. Hence, we propose that there is another, better option to be used in the empirical analysis, that is, the shadow rate.

Theoretically, when the nominal interest rates reach the ZLB, many economic models cease to function. It is due to the fact that while such models, for example, the Gaussian affine term structure models, are linear in Gaussian factors and allow nominal interest rates to go below zero, the term structure data are constrained by the ZLB (Wu & Xia, 2016). Additionally, according to Kim and Singleton (2012), the term premia in such a model are biased as the model opts to prescribe quick reversion to the long-term mean inadequately. Hence, researchers have come up with a "shadow rate" to be used as a substitute for the policy rate in affine term structure models to make those models functional again. The original idea of a shadow rate was proposed by Black (1995). He suggested a new way to measure the call option to hold cash at the ZLB. The value of such an option will be deducted from the nominal yields to derive the shadow nominal yield curve. The shadow rate has been used to quantify the impacts of unconventional monetary policy on the economy in many recent studies.

Wu and Xia (2016) tested the null hypothesis of whether the (regression) parameters on the relevant macroeconomic variables in a model for the shadow rate under the ZLB are similar to those of macroeconomic variables affecting the Fed funds rate in the normal times. They could not reject the null hypothesis that there is no difference in the impacts of the proposed new (implicit) policy rate (i.e., the shadow rate) before and during the ZLB era. Subsequently, they replaced the shadow rate with the Fed funds rate and noticed that there was a structural break with respect to the ZLB period. They inferred that the shadow rate is an appropriate substitute for the policy rates especially during the periods of unconventional monetary policy conditions, and hence, can be used to extend those studies that had been based on such rates to more recent periods, too. Furthermore, they affirmed the effectiveness of the unconventional monetary policy tools in lowering the shadow rate and hence, creating positive impacts on the general economy. To be more specific, if there had not been the unconventional interventions of the Fed during the analysed time period after GFC, the unemployment rate would have been 0.13% higher, and the capacity utilization would have been 0.3% lower than observed. They also extended their research on the role of individual tools of the non-conventional monetary policy, and again, the shadow rate surpassed the Fed funds rate in conveying meaningful information when the Fed fund rate was stuck at the zero level.

Turning back to the euro area, Kortela (2016) has argued that a constant lower bound in the shadow rate term structure model that has been used earlier was only a good fit for the U.S data. It is because the Fed funds rate, in other words, the main monetary policy stance reflector of the U.S. economy, supports the idea of a constant lower bound. Regarding the Euro system, the ECB regulates the short-term interest rates based on the key policy rates (e.g., the deposit facility rate, DFR). Since this rate is neither constrained to any bounds nor constant, it is unreasonable to set a constant lower bound for it either. Hence, he proposed another option: the time-varying lower bound, for the shadow rate term structure model. Furthermore, he also acknowledged that even a minor change in the lower bound triggers substantial changes in the shadow rate. The sensitivity of the shadow rate has made it an inefficient measure of the monetary policy stance to many scholars (e.g., Bauer & Rudebusch, 2016; Christensen & Rudebusch, 2016). However, the shadow rate derived by Kortela (2016) shows a high negative correlation with the lift-off horizon measure, which is generally regarded as a reasonable measure of the stance of monetary policy. Therefore, he concluded that the shadow rate with the time-varying lower bound is valid. Comparing to the shadow rates proposed by Krippner (2015a and b) and Wu and Xia (2016), who both deployed the constant lower bound, the shadow rate used by Kortela exhibits a high correlation with those.

Our preferred choice of shadow rate measure introduced by Kortela (2016) for the euro area banking sector is based on the following reasoning. Compared to the other possibility, i.e., the Wu and Xia (2016) shadow rate series available from Cynthia Wu's page at *https://sites.google.com/view/jingcynthiawu/shadow-rates*, the series based on Kortela (2016) is calculated from observations of overnight index swaps (OIS) that are considered as good proxies for risk-free rates in the whole Euro area. In these swaps, one party exchanges a fixed payment over a nominal amount and receives for each day of the term contract a floating rate referenced on the €STR that reflects the wholesale unsecured overnight borrowing costs of euro area banks in general. Hence, when compared to some other, previously utilized measures of risk-free rate, like the German government bond yields, adapted to represent the whole Euro area risk-free rate in many previous studies, we propose the shadow rate to be an even more valid measure for it. Furthermore, as the swaps do not involve exchange of notional amount, the OIS contracts are not subject to the similar counterparty risk as for example some other money market instruments. As the OIS rates are affected by changes in the ECB's DFR and QE, they reflect the market's expectations of the future path of the monetary policy, too. The novelty of the shadow rate is recently reaffirmed by Soenen and Vander Vennet (2021). They justified that the shadow rate does not only break the typical norm that policy rates could not pass through ZLB, but also captures effects rooted in monetary policy measures that do not directly aim at central banks' balance sheet (e.g., OMT). Along with that, the shadow rate encompasses anticipations of market participants in the long run, as its estimation allows for the entire yield curve.

2.2.4. Sovereign bond markets and unconventional monetary policy

As specified in earlier parts, the sovereign risk premium is constructed from two constituents, the sovereign bond yield and shadow rate. The latter one has been covered in the previous part. In addition, we hold the view that the country-level bond yield also plays a role here, because already when the consequences of the GFC had not fully materialized, countries in the Eurozone area had to face another globally effective crisis – the Sovereign Debt Crisis. One of the main reasons that lead to the European debt crisis was that although countries in the Eurozone have shared a unified monetary policy governed by the ECB, they still have conducted their fiscal policies as sovereign entities. While the common monetary policy actions determine the money supply, and hence, affect the interest rates in the market, the fiscal policy involves balancing the public budget and expenditures of a nation. As the euro area became a united bloc, peripheral countries such as Spain, Ireland, and Portugal had access to low-cost funding without so many strict obligations as before. Lenders had stronger reasons to believe that if those countries were facing insolvency, other, especially the big Eurozone economies would jump in and repay the debt as they were bound to each other. As a result, the public spending of those countries skyrocketed to a previously unforeseen levels, and the aggregate economy of Europe intertwined as the amount of debt increased.

In late 2009, Greece announced that it was unable to repay and refinance its debt obligations, revealing that its sovereign debt shot up to 113% of GDP and a deficit of 13.6% of GDP, which were much higher than the intentionally misreported figures earlier. Shortly afterwards, peripheral countries from Eurozone witnessed an unprecedented surge in the sovereign bond yields as investors demanded substantially more returns for the fear of sovereign default. Consequently, the ECB decided to purchase the government debt of indebted euro area countries under the Securities Markets Program (SMP) and Outright Monetary Transactions (OMT) program to avoid the contagion of shocks across the Eurozone debt markets (Ehrmann & Fratzscher, 2017).

Most parts of the previous literature have focused on how the ECB actions are in connection to the evolution of sovereign bond yields. For example, Saka, Fuertes, and Kalotychou (2015) examined whether the ECB's monetary policy stance, and as one of most strikingly clear examples of its forward guidance nature, the speech of ECB President Mario Draghi on July 26th, 2012, to do “whatever it takes” to preserve the euro, is effective in curbing the self-fulfilling dynamics. Self-fulling dynamic is defined as a chain of events where investors conjecture that the sovereign risk default is high, thus requiring higher interest returns. In turn, this presumption makes it harder for the sovereign to refinance its debts, which ultimately could result in a liquidity crisis and actually the feared default. Saka et al. employed a principal component analysis in their study and revealed that the Draghi's implicit announcement about the OMT program had a containing effect on the self-fulfilling dynamics, which occurred in the Eurozone during the period after the GFC.

In a similar fashion, Ehrmann and Fratzscher (2017) found that the euro area bond markets were fragmented at the end of the crisis, as a result of the ECB attempt to contain the crisis within borders of each country. They realized that the flight to quality (i.e., the case in which the shock that increases yields in peripheral countries would reduce yields in the core countries, too) dispersed after the speech about the OMT program. The only sign of contagion indicated by the result was the one between Italy and Spain. The results implied that countries were efficiently ring-fenced, and Italy and Spain benefited from the joint reduction in the sovereign yields following the OMT announcement.

Other studies, in general, yield similar results that the ECB's actions have been successful in winding down the high peaks of sovereign bond yields in the euro area. Eser and Schwaab (2016) examined the SMP interventions in the government debt securities markets of the distressed PIIGS-countries (i.e., Greece, Ireland, Italy, Portugal, and Spain) between 2010 and 2011. They deployed a panel data strategy, but instead of using a simple regression, which neglects the effects of other common factors (i.e., the escalating ESDC), they used a factor structure, which enabled them to control for the cross-sectional dependence. In short, based on their results, ECB's intervention had an adverse impact on sovereign bond yields, and this impact varied among the Eurozone states depending on the sizes of the respective markets. Furthermore, ECB's asset purchases enhanced the liquidity conditions and reduced the default-risk premia. This result is in accordance with those of Rogers, Scotti, and Wright (2014), Beber, Brandt, and Kavajecz (2009), and Pelizzon, Subrahmanyam, Tomio, and Uno (2015).

In some recent studies, researchers have studied the impacts of other non-conventional monetary policy tools, e.g., Quantitative Easing (QE) program on the sovereign bond markets. Against the common perception that this unconventional tool only comes into effect during financial crises, Altavilla, Giannone, and Lenza (2016) acknowledged the sizeable impacts of large asset purchase program (APP) on long-term sovereign bonds (at 10-year maturity) even during stable financial conditions. This is validated by the fact that even though a period of low financial distress weakens the transmission channel of the unconventional policy tools, it also enhances other channels as it interplays with the asset composition of the program. They also emphasized that the adverse effect is more prominent in high-yield countries such as Italy and Spain. These results were supported also by De Santis (2016) when he analysed the impacts of APP on the government bond yields, using the Bloomberg news data on euro area APP. According to these results most of the impacts occur even before the purchases actually take place, mainly due to the implicit announcement one year in advance.

2.2.5. Impact of bank-level characteristics on profitability

Besides the effects of policy rates on bank profitability, other factors should also be included in the estimated bank profitability models to control for the bank-level characteristics. Evidently, bank size is one relevant determinant of profitability. Large banks tend to have better access to a larger variety of funding sources, and they have better cost management strategies and ability to diversify their portfolios and businesses more aggressively. According to Goddard, Molyneux, and Wilson (2004) and Mirzaei, Moore, and Liu (2013), profits correlate positively with the bank size through the economies of scale. On the other hand, Demirgüç-Kunt and Huizinga (1999) and Demirgüç-Kunt, Laeven, and Levine (2004) have suggested that the bank size may be a decisive factor of NIM if there are increasing returns to scale in banking. Also, Shehzad, Haan, and Scholtens (2013) studied the connection between bank size, growth, and profitability, using a large dataset consisting of more than 15,000 banks from 148 countries from 1988 to 2010. Their results support the hypothesis that the volatility of bank profits and bank size are independent. However, they confirmed that bigger banks yield more profits in high-income OECD countries despite growing more slowly than small banks. Therefore, there is reason to believe that large banks are able to offset the impacts of low and negative market rates on NIM and profitability more efficiently.

The capital ratio is deemed to be another factor that alters bank profitability. Berger and Bouwman (2013) have stated that capital adequacy enhances banks' performance. The capital supplement helps small banks to increase the probability of survival. Meanwhile, previous empirical evidence shows also that medium-sized and large banks improve their profitability by strengthening their capital during financial crises. Several studies, like McShane and Sharpe (1985), Saunders and Schumacher (2000), Maudos and Fernández de Guevara (2004) have used the capital ratio (i.e., the ratio of equity over total assets) as a proxy for risk aversion. Bank's capital ratio and profitability are expected to be positively connected since the more risk-averse a bank is, the more profits it will require to cover the higher costs of equity.

Customer deposits are the primary source of bank funding. Banks that have abundant deposits are able to increase their loan supply, thus increasing the banks' NIM. Many studies have examined the relationship between bank deposits and profitability in different markets (e.g., Naceur & Goaied, 2001; Trujillo-Ponce, 2013). Most of these results show that increasing deposit funding positively correlates with banks' profits, regardless of which measure is used to measure profitability.

Other bank-level characteristics such as liquidity, credit risk, cost efficiency, and bank diversification are prone to have impacts on bank profitability as well. A high amount of liquid assets, on one hand, means that banks are less vulnerable when there is a large deposit withdrawal. On the other hand, if banks keep unnecessarily large amounts of cash and reserves, interest income will lower as such assets typically generate relatively low margins. Credit risk is the risk that loans become irrecoverable. In prior studies (Almarzoqi & Naceur, 2015; Carbó Valverde & Rodríguez Fernández, 2007; Poghosyan, 2013), higher credit risk implies that banks are exposed to a higher probability of solvency. Thus, those banks require a premium to margins as a compensation for bearing the risk. Nevertheless, higher credit risk also indicates that banks have a high amount of non-performing loans, which could compress the profit margins in the future, too.

Cost efficiency measures the ability to manage the costs of banks. A lower cost ratio indicates high efficiency (i.e., banks are more able to pass the operating expenses to depositors and lenders through deposit and lending rates), making the margins larger (see Abreu & Mendes, 2003; Maudos & Fernández de Guevara, 2004; Tarus, Chekol, & Mutwol, 2012). Non-interest income (e.g., fees and commissions, etc.) contributes to banks' overall profits, apart from interest income. There is some evidence suggesting how far banks have recently been driven away from their traditional activities. According to Stiroh (2002, 2004), a deviation from banks' core business will result in a decrease in interest margins. However, because it is part of the overall profitability of a bank, non-interest income plays a vital role for banks in crises when the interest margin is squeezed.

3. Data and methodology

3.1. Data description

We apply a panel data model to examine the impact of the sovereign risk premium on the bank profitability indicators. At the beginning, a bank-level dataset of 404 active banks across the euro area, excluding Cyprus, Estonia, Latvia, Lithuania, and Malta, was obtained from Moody's Analytics BankFocus database, covering the observations between 2005 and 2019. The dataset includes yearly bank-level financial variables of commercial banks, savings banks, and cooperative banks. However, to obtain a balanced set of observations for all variables in the time dimension, the banks having missing observations more than 40% of the total time span of 15 years were eliminated from the analysis. After this filtering, 154 banks were qualified for further analyses. Furthermore, the full dataset will be broken into two subgroups for the subsample analysis, which includes significant and less significant banks. The criterion to determine whether a bank is significant is based on that of the ECB, where the banks with the value of total assets exceeding €30 billion are classified as significant banks. After splitting, the number of significant and less significant banks was 62 and 92, respectively. For clarity, from now on the terms “large” and “small” are used interchangeably to imply “significant” and “less significant” banks.

Additionally, since we are focusing on the role of government bond markets in our analysis, it is also necessary to analyse the data in view of the comparison between the GIIPS versus non-GIIPS banks, GIIPS referring to Greece, Ireland, Italy, Portugal, and Spain, while non-GIIPS refers to the rest of the euro area countries. This analysis is essential due to two primary reasons. First, GIIPS countries are the main parties in the ESDC. Second, public discussions and some media reports are frequently claiming that the northern Eurozone banks are paying unnecessary costs in one form or other (e.g., lower market value compared to the fundamentals) due to the more tightened regulation, which results from the poor performance of southern banks in terms of risk-adjusted fundamentals. For example, Banerjee and Mio (2018), although they examined a different set of data (focusing on British banks), found that the liquidity regulations negatively influence banks' profitability because such banks had to switch to low-yield liquid assets in their asset management activities. To give some new research-based background for these discussions, the data utilized in this study consists of 44 banks from GIIPS and 110 banks from non-GIIPS countries. More details on the data collection are given in Appendix 1.

One critically new focus of our analysis compared to the previous papers is that the shadow rate is deployed instead of other money market rates, for example, the EONIA mid-rate or Euribor rates. After the GFC and GR (2008–2013) and again, to an exceptionally large extent, during the COVID-19 crisis, ECB has utilized the non-conventional monetary policy tools extensively in the hope of boosting inflation and especially real economic growth. However, economists have difficulty in quantifying the effects of unconventional monetary policy tools because the traditional economic models basically (e.g., for the part of the role of interest rate in the basic discounting ideas) stop working when the key interest rates hit the ZLB. However, as discussed before, the shadow rate, which incorporates the role of many macro-economic factors, can enter (and has entered for a longer period of time since 2014) deep into the negative territory. Thus, it can be the potential indicator of Euro area *efficient monetary policy stand*, as has been suggested by Wu and Xia (2016). In addition, as seen from Fig. 2, where we see the development of the euro area shadow rate in our sample period based on the work of Kortela (2016),[5] the shadow rate is probably able to forecast the development of EONIA a few months in advance, and the correlation between those two is very high up until the quotation of the negative interest rates started in 2014. However, during the negative interest rate period (NIRP), their close connection vanishes, due to the fact, that the variance of EONIA Midrate has been almost zero, whereas the shadow rate has varied much more strongly, due to its stronger ability to reflect the aggregate, real economic conditions during the NIRP.

The annual average rate of the ECB shadow rate was calculated by taking the arithmetic mean of monthly rates provided in the original dataset. The sovereign risk premium or return requirement for the country where a bank is domiciled in excess of this common monetary policy steering rate proxy is derived by taking the difference between the 10-year government bond yield and the shadow rate. Government bond yields for each country between 2005 and 2019 were taken from the REFINITIV/Eikon Datastream.

Another new dimension of our analysis is that besides the most standard ROA- or ROE- based performance measures, we use a risk-weighted performance indicator, i.e., the return on risk-weighted assets (RORWA), available from the BankFocus, too. Since the detailed compositions of these three profitability indicators are totally different, they are expected to give somewhat different perspectives on the profitability effects of the low and negative interest rate era. Junttila et al. (2021) have noted that it is essential to analyse the bank profitability using both the risk-adjusted and standard profitability measures as they noticed that the final impacts of money market rates through the effects on the NIM are different, depending on which overall profitability measure is used. More details on the measurement of the analysed variables are provided in Appendix 2. In addition, Tables 1 and 2 provide the descriptive statistics on the variables.

In overall terms, the average ROA and ROE profitability of Euro area banks from 2005 through 2019 is 0.47% and 5.28%, respectively. On the other hand, compared to these traditional measures, the average return on risk-weighted assets (RORWA) during this time is very high (88.74%). This unrealistically high figure might be due to the impacts of outliers. The median figure of this indicator provides more evidence for the existence of extreme outliers, because the median value of return on risk-weighted assets (RORWA) is 1.37%. The average sovereign risk premium is 2.42%. The average leverage ratio (i.e., the amount of total customer deposits over total assets) of the analysed euro area banks is 49%, which is fairly high.

Concerning the development of the sovereign bond yields, Fig. 1 shows that the yields of GIIPS and non-GIIPS countries move relatively close to each other. However, the turning point in the data series seems to be the second half of 2008 when the yields started to diverge. The government bond yields in GIIPS countries gradually built up, and the spread between their bond yields and non-GIIPS countries' bond yields increased from nearly 0% (from 2004 to 2007) to approximately 7% in 2012, when it reached its peak. For some individual countries this dispersion, for example for the case of Greece vis-à-vis Germany was even more massive. Fig. 1 also depicts that the President Mario Draghi's speech on July 26th, 2012 (denoted by the vertical red line), considerably eased off the sovereign bond market for especially the GIIPS countries. Again, this fact emphasizes the role of unconventional monetary policy tools and justifies our selection of the newly defined sovereign risk premium.

From Fig. 2 we note clearly that the shadow rate has continued to move deeper into the negative territory since 2014, unlike EONIA. It reached the lowest value in our sample in 2016 at approximately −2.8%, before rising back and ending to the level of −2.1% in 2019. On the other hand, from Fig. 3 we see that the mean values for the return on average assets (ROAA), return on average equity (ROAE), and return on risk-weighted average assets (RORWA) for the whole bank dataset all increased from 2014 to 2019 but with different growth rates. On the contrary, the NIM marginally decreased during the same period, which is a plausible finding during the trend-wise lowering of market interest rates.

3.2. Methodology

3.2.1. Difference GMM approach

Due to the problems related to the possible endogeneity of some of the analysed variables treaded as independent variables in the bank profitability regressions, our empirical analysis mainly involves using the differenced generalized method of moments (DGMM) method, and here we give a short description of this method based on Wooldridge (2010) and Kripfganz (2019). We start from a general (linear) regression model of the form

$$y_i = X_i\beta + u_i \tag{1}$$

where y_i and u_i are $N \times 1$ vectors of variables and the error term, β is a $K \times 1$ vector of unknown parameters, and X_i is a $N \times K$ matrix of explanatory variables. Assume next that Z_i is a $N \times L$ ($L \geq K$) matrix of instrumental variables and it is uncorrelated with the error term, so

$$E\left(Z_i' u_i\right) = 0. \tag{2}$$

Under these assumptions, β should be the unique solution to solve the linear set of population moment conditions, i.e.

$$E\left[Z_i'(y_i - X_i\beta)\right] = 0. \tag{3}$$

In other words, if there is another $K \times 1$ vector of b in which at least one component is different from the corresponding component in β, then

$$E\left(Z_i'(y_i - X_i b)\right) \neq 0. \tag{4}$$

Eq. (4) indicates that β is identified. The same principle is applied to the whole sample of variables as the sample means are consistent estimators of population moments. In this case, $\widehat{\beta}$ should be the unique solution that solves

$$\frac{1}{N}\sum_{i=1}^{N} Z_i'(y_i - X_i\widehat{\beta}) = 0. \tag{5}$$

If the model is over-identified (i.e., >K), implying that the number of instruments exceeds the number of main regression equation variables, then a solution is unlikely to exist. The reason is that there are more constraints than needed for the estimation, and it is unlikely that redundant constraints are exactly the same in any subsamples. Thus, the generalized method of moments estimator is deployed to minimize the quadratic form

$$\min_b \left[\sum_{i=1}^{N} Z_i'(y_i - X_i b)\right]' W \left[\sum_{i=1}^{N} Z_i'(y_i - X_i b)\right]. \tag{6}$$

For the estimator to be asymptotically efficient, the $L \times L$ weighting matrix W should be optimal (i.e., matrix W should be a consistent estimate of the inverse of the asymptotic covariance matrix of $Z_i'(y_i - X_i b)$), so

[5] The data on the ECB's shadow rate, which covers the monthly observations between 1999 and 2019 was provided by Tomi Kortela at the OP Group.

Table 1
Descriptive statistics – Full sample.

	N	Mean	Std. Dev.	min	p25	Median	p75	max	VIF
ROAA	1810	0.471	0.976	−13.519	0.252	0.473	0.773	8.908	–
ROAE	1808	5.288	13.406	−231.402	3.565	5.839	8.76	81.889	–
RORWA	1269	88.747	3117.316	−29.37	0.564	1.374	1.99	111,049.45	–
NIM	1977	1.718	1.064	−16.31	1.184	1.58	2.037	9.647	–
sovereign risk	2292	2.421	1.656	0.057	1.318	2.229	3.253	22.351	1.30
bank size	1977	10.257	1.762	6.212	9.205	9.871	11.271	14.605	1.67
cap adequacy	1977	8.849	5.072	−3.931	5.633	8.226	11.559	75.934	1.58
cus deposit	1959	49.131	21.289	0	29.999	52.384	65.393	99.641	1.25
liquidity	1964	3.309	5.602	0	0.538	1.238	3.67	61.341	1.08
cost efficiency	1977	63.257	59.162	−1747.805	55.934	63.251	71.267	438.105	4.85
credit risk	1821	5.814	7.806	0.038	2.022	3.277	5.894	99.676	1.28
bank div	1977	46.758	54.32	−147.986	35.833	45.154	52.627	1674.146	4.95
wholesale fund	2004	41.608	23.189	0	25.178	37.652	59.977	100	–
loss provision	1938	0.508	3.405	−73.451	0.122	0.286	0.657	80.718	–

Notes: SOVEREIGN RISK – sovereign risk premium; BANK SIZE – bank size; CAP ADEQUACY – Capital adequacy; CUS DEPOSIT – customer deposit; LIQUIDITY – liquidity; COST EFFICIENCY – cost efficiency; CREDIT RISK – credit risk; BANK DIV – bank diversification; ROAA – returns on average assets; ROAE – returns on average equity; RORWA – returns on risk-weighted assets; NIM – net interest margin; WHOLESALE FUND – wholesale funding ratio; LOSS PROVISION – loan loss provision. See Appendix 2 for the exact definitions, data sources, and actual measurement of all the variables based on the bank's income statement and balance sheet information reported in BankFocus and other sources of data. *N* refers to the number of observations, and in addition to the mean, standard deviation, minimum, maximum, median and the first and fourth quartile values, in the last column the variance inflation factor (VIF) is reported for the part of regressors utilized in the main regression model.

$$W = \left\{ \frac{1}{N} \sum_{i=1}^{N} \left[Z_i'(y_i - X_i b) \right] \left[Z_i'(y_i - X_i b) \right]' \right\}^{-1}. \quad (7)$$

The initial purpose is to estimate the value of $\widehat{\beta}$ that could solve Eq. (6). However, it now involves using the optimal matrix *W*, which is unknown. Therefore, the feasible efficient two-step GMM is utilized. First, *W* can be obtained from an inefficient initial GMM estimator based on some suboptimal choice of *W*. Then, the residual derived from the model which deploys the suboptimal choice of W would be used inversely to construct the optimal weighting matrix in the efficient two-step GMM based on minimization of

$$\min_b \left[\sum_{i=1}^{N} Z_i'(y_i - X_i b) \right]' \widehat{W} \left[\sum_{i=1}^{N} Z_i'(y_i - X_i b) \right]. \quad (8)$$

Assume next that a relevant dynamic panel data model for the analysed variables can be given as

$$y_{it} = \gamma y_{i,t-1} + \beta x_{it}' + \alpha_i + u_{it}, \quad (9)$$

where α_i are the (unobserved) individual effects, and x_{it} is a matrix of $N \times K$ observations on time-varying explanatory variables. There are two potential crucial problems when dealing with such a model. The estimators γ and β are biased and inefficient for two reasons: (1) the interaction between explanatory variables (i.e., $y_{i,\,t-1}$and x_{it}) and individual effects (i.e., α_i); and (2) the interaction between explanatory variables and residuals (i.e., u_{it}). Demeaning or taking the difference (i.e., $\Delta y_{it} = \rho \Delta y_{i,\,t-1} + \beta \Delta x_{it} + \Delta u_{it}$) enables to sweep out the individual effects. However, this approach will lead to the second problem, which is the endogeneity dilemma. Specifically, Δy_{it} is a function of $\Delta u_{it} = u_{it} - u_{i,\,t-1}$. Likewise, $\Delta y_{i,\,t-1}$ is a function of $\Delta u_{i,\,t-1} = u_{i,\,t-1} - u_{i,\,t-2}$. Thus, $\Delta y_{i,\,t-1}$ will correlate with the differenced residual Δu_{it} through $u_{i,\,t-1}$. In other words, $\Delta y_{i,\,t-1}$ is deemed to be the endogenous variable. If only one explanatory variable is endogenous, the estimated coefficients of the remaining variables are affected regardless of those variables being exogenous.

For the purposes of our empirical analyses, where it is obvious that the problem of endogenous variables on the right-hand side of the main regression model (9) is very relevant, the DGMM method is effective in handling endogeneity of the lagged dependent variable in a dynamic model, omitted variables bias, and unobserved panel heterogeneity. Nevertheless, this method also has its limitations. First, it is a complicated estimation method and easily generates invalid estimates (Roodman, 2006). Second, it does not account for the cross-sectional dependence or for structural breaks in the data. Furthermore, it is not suitable for panel data sets with very long time series either. Third, if there are too many instruments used, the *p*-value for post-tests becomes implausible. The literature is still not clear on how many instruments would be "too many" (Roodman, 2006). Hence, in our empirical analyses we adopt the following strategy.

3.2.2. *Estimation strategy*

In our empirical analysis, we will start from the standard panel regressions. As can be seen from the results reported in the online Appendix 3, the results from Breusch and Pagan (1980) Lagrange multiplier test for random effects indicate that using the generalized least squares models for the data on ROAA, ROAE, and NIM is appropriate. Meanwhile, the results for the analysis of RORWA profitability failed to reject the null hypothesis that variances across entities are zero. In other words, there are no panel cross-sectional effects. Hence, regarding RORWA, pooled ordinary least squares method was deployed as the next step.

Second, the Hausman (1978)-test (see again Appendix 3) was used to select between the fixed effects and random-effects models. The results justified the choice of fixed effects model for the models for ROAA, ROAE, and NIM. Because the error terms in these three fixed effects models were heteroscedastic and serially correlated, the robust standard errors approach was utilized.

Third, as discussed in the previous subsection, the obviously necessary dynamic term in the regression model correlates with the error term, which results in one form of endogeneity. Furthermore, because in our analyses the shadow rate itself is a generated regressor based on another model originally (i.e., the shadow rate term structure model), efficient estimation of a model that includes the shadow rate in one form or other requires GMM-type regressions, as already Pagan (1984) has pointed out. Hence, the DGMM approach might be the appropriate technique to deal with the endogeneity problem and potential omitted variables bias in the models. Blundell and Bond (1998) and Windmeijer (2005) have shown that the two-step generalized method of moments estimation (unlike the one-step GMM) provides consistent and efficient results given both heterogeneity and autocorrelation.

In other words, the fundamental regression models estimated for our profitability analyses (for the notations see Table 1) are given as

Table 2
Pairwise correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) ROAA	1.00													
(2) ROAE	0.85***	1.00												
(3) RORWA	0.02	0.01	1.00											
(4) NIM	0.05*	0.02	−0.01	1.00										
(5) sovereign_risk	−0.29***	−0.28***	−0.04	0.10***	1.00									
(6) bank_size	−0.17***	−0.06*	−0.01	−0.17***	0.01	1.00								
(7) cap_adequacy	0.26***	0.03	0.04	−0.01	−0.03	−0.45***	1.00							
(8) cus_deposit	0.02	0.07**	−0.04	0.21***	0.10***	−0.29***	−0.07**	1.00						
(9) liquidity	0.00	−0.01	−0.02	0.05*	−0.02	−0.03	0.02	0.11***	1.00					
(10) cost_efficiency	−0.05*	0.01	−0.00	−0.07***	0.03	0.00	0.08***	0.04*	0.04	1.00				
(11) credit_risk	−0.31***	−0.29***	−0.02	0.31***	0.45***	−0.06*	0.05*	0.07**	0.02	0.03	1.00			
(12) bank_div	0.02	−0.03	0.00	−0.18***	−0.05*	0.01	0.03	−0.13***	0.03	−0.84***	−0.06**	1.00		
(13) wholesale_fund	0.01	−0.06*	0.04	−0.19***	−0.11***	0.14***	0.13***	−0.96***	−0.14***	−0.05*	−0.08***	0.12***	1.00	
(14) loss_provision	−0.16***	−0.16***	−0.00	0.20***	0.12***	0.03	−0.20***	0.02	0.02	−0.03	0.48***	−0.04	−0.01	1.00

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$ refer to the significance at 10, 5 and 1% risk levels, respectively. For the other notations, see the notes below Table 1.

$$ROAA_{it} = \beta_1 ROAA_{i,t-1} + \beta_2 ROAA_{i,t-2} + \beta_3 sovereign\_risk_{it} + \beta_4 bank\_size_{it} + \beta_5 cap\_adequacy_{it} + \beta_6 cus\_deposit_{it} + \beta_7 liquidity_{it} + \beta_8 cost\_efficiency_{it} + \beta_9 credit\_risk_{it} + \beta_{10} bank\_div_{it} + \theta_t + \alpha_i + \varepsilon_{it};$$

$$ROAE_{it} = \beta_1 ROAE_{i,t-1} + \beta_2 ROAE_{i,t-2} + \beta_3 sovereign\_risk_{it} + \beta_4 bank\_size_{it} + \beta_5 cap\_adequacy_{it} + \beta_6 cus\_deposit_{it} + \beta_7 liquidity_{it} + \beta_8 cost\_efficiency_{it} + \beta_9 credit\_risk_{it} + \beta_{10} bank\_div_{it} + \theta_t + \alpha_i + \varepsilon_{it};$$

$$RORWA_{it} = \beta_1 RORWA_{i,t-1} + \beta_2 RORWA_{i,t-2} + \beta_3 sovereign\_risk_{it} + \beta_4 bank\_size_{it} + \beta_5 cap\_adequacy_{it} + \beta_6 cus\_deposit_{it} + \beta_7 liquidity_{it} + \beta_8 cost\_efficiency_{it} + \beta_9 credit\_risk_{it} + \beta_{10} bank\_div_{it} + \theta_t + \alpha_i + \varepsilon_{it}; \text{ and}$$

$$NIM_{it} = \beta_1 NIM_{i,t-1} + \beta_2 NIM_{i,t-2} + \beta_3 sovereign\_risk_{it} + \beta_4 bank\_size_{it} + \beta_5 cap\_adequacy_{it} + \beta_6 cus\_deposit_{it} + \beta_7 liquidity_{it} + \beta_8 cost\_efficiency_{it} + \beta_9 credit\_risk_{it} + \beta_{10} bank\_div_{it} + \theta_t + \alpha_i + \varepsilon_{it}.$$

Finally, because the main concern of all our empirical analyses is in the relationship between the sovereign risk premium and bank profitability during the low and negative rate era, it is reasonable to include the interaction term to distinguish different stages of monetary policy. All the main central banks have applied zero policy rates since 2012, and the key interest rates in the euro area remained at very low levels until the mid of 2014 before officially entering the negative zone. Hence, the dummy variable"*before* 2012", which takes the value of one for the period before 2012 and zero otherwise, is deployed. Based on this representation of the regression model, the individual coefficient of *sovereign_risk* will directly describe the effect of sovereign risk premium on bank profitability under low and negative rates. On the other hand, this effect before 2012 is derived by taking the sum of the interaction term *sovereign_risk* × *before* 2012 and the individual coefficient on the sovereign risk premium.

4. Empirical results and discussion

4.1. Impact of sovereign risk premium on banks' overall profitability

Empirical results for the impacts of sovereign risk premium on banks' overall profitability are presented in Tables 3 –5. First and foremost, we see that the sovereign risk premium influences both the non-risk-adjusted and risk-adjusted profitability indicators. Furthermore, this effect is negative for all of them, except for the risk-adjusted measure, when the estimation is based on the fixed effects method, because the parameter estimate gets to be estimated in that case with a very large standard error.

Based on the results reported in Table 3, with respect to the return on assets, a 1 percentage point increase in the sovereign risk premium leads to a 0.2 percentage point decrease in ROAA during the low and negative rate regime. This effect is significant at 1% level and gets to be amplified in the GMM estimation results. Assuming other factors remain unchanged when the sovereign risk premium rises, in practise it means that either the government bond yield increases, or the shadow rate decreases. This fact implicitly implies that the shadow rate has a positive effect on ROAA, which is consistent with the findings from several previous studies (Borio et al., 2017; Demirgüç-Kunt & Huizinga, 1999) investigating the relationships between other short-term, monetary policy rates and bank profits. Interestingly, this effect seems to have diminished under the low and negative rates era. More specifically, the effect of sovereign risk premium on ROAA during the period prior to 2012 (represented by the sum of the estimated coefficients on the original "sovereign risk" and the interaction variable) is more severe. This drastic impact might be the result of the GFC during 2007–2008.

For the part of subsample analysis (see the online Appendix 4), our empirical results suggest that smaller banks are more affected by the

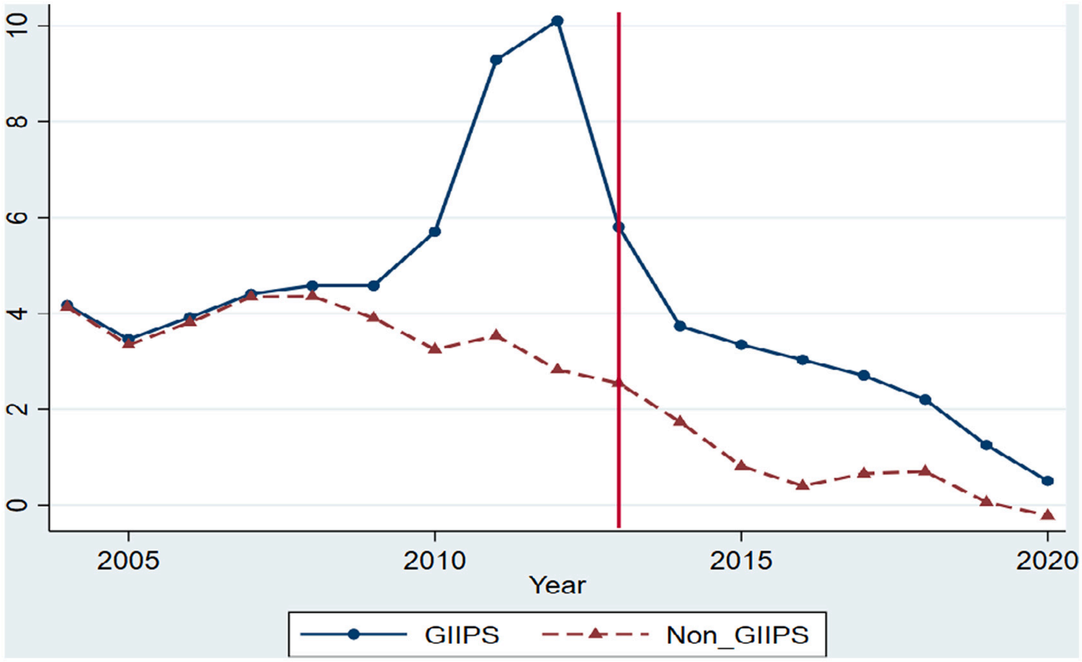

Fig. 1. Development of sovereign bond yields in GIIPS and non-GIIPS countries, on average. The red vertical line depicts President Draghi's 'whatever it takes' speech in July 2012. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

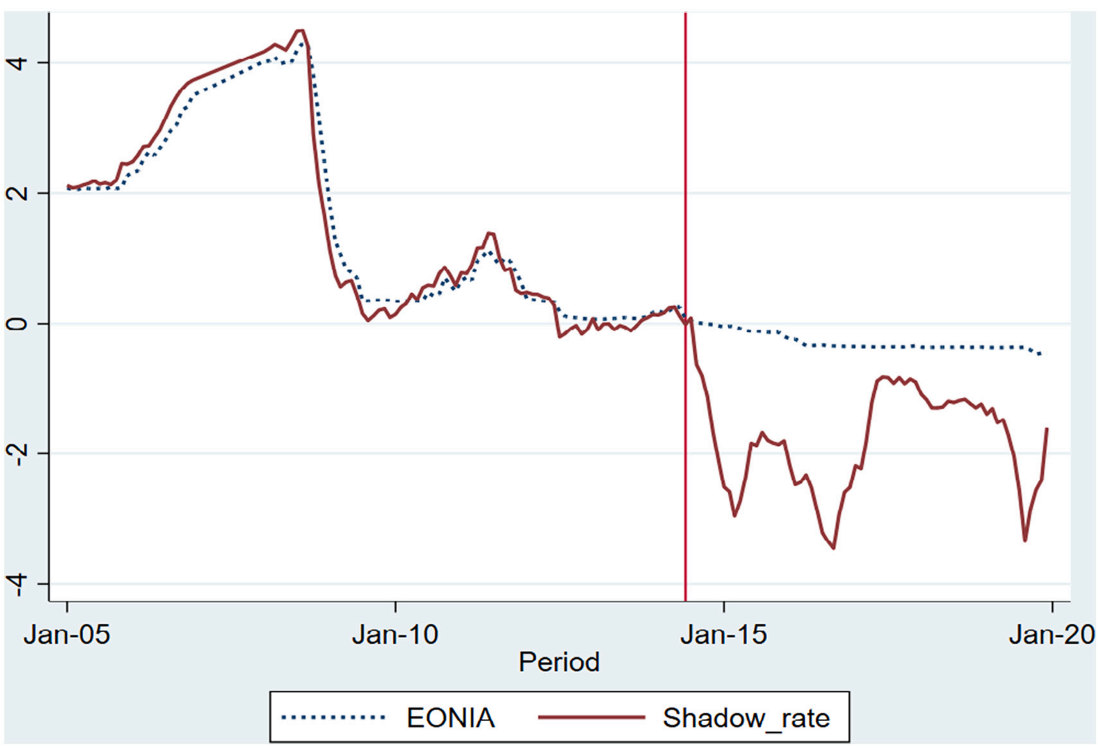

Fig. 2. Development of the euro area shadow rate and the Euro Overnight Index Average (EONIA) midrate. The red vertical line refers to the exact point of time when both interest rates started to obtain only negative values. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

sovereign risk premium. The corresponding coefficient for the case of small banks is −0.52, whilst that of large banks is in absolute terms much smaller, −0.13 (see Appendix 4). Both these coefficients are statistically significant at the 10% risk level. Regarding GIIPS banks (results given in Appendix 5), the sensitivity of ROAA to the sovereign risk has diminished since the low and negative rate policy took effect. Furthermore, during the financially distressed era (before 2012), the effect of the sovereign risk premium, which was driven mainly by the surge in bond yields during the ESDC, on ROAA is massive. An increase of 1 percentage point in the sovereign risk premium triggers ROAA of GIIPS banks to decrease by a 0.64 percentage point (the sum of the interaction term and the original coefficients, see Appendix 5). In other

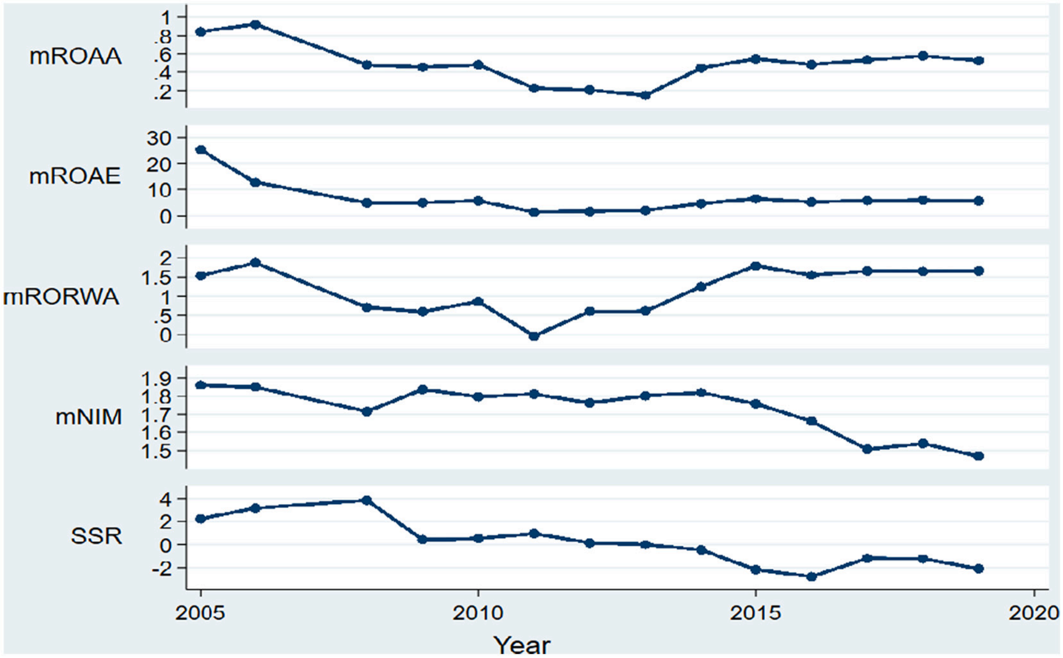

Fig. 3. Development of bank profitability measures and shadow rate. mROAA is the mean return on average assets, mROAE is the mean return on average equity, mNIM the mean net interest margin, and SSR the euro area shadow rate.

Table 3
Effect of sovereign risk premium on ROAA - full sample.

	Model 1: Fixed Effects	Model 2: Two-step DGMM
	ROAA	ROAA
sovereign_risk	−0.153***	−0.220***
	(0.0526)	(0.0776)
sovereign_risk x before 2012	−0.215	−0.267**
	(0.151)	(0.128)
bank_size	0.218	0.819**
	(0.150)	(0.392)
cap_adequacy	0.115***	0.279***
	(0.0211)	(0.0800)
cus_deposit	0.0102**	0.0101
	(0.00462)	(0.00978)
liquidity	−0.0164***	−0.0125
	(0.00535)	(0.0138)
cost_efficiency	−0.00842	−0.00838
	(0.00522)	(0.00687)
credit_risk	−0.0296	−0.0778***
	(0.0232)	(0.0212)
bank_div	−0.00869	−0.00888
	(0.00540)	(0.00720)
L.ROAA	–	−0.167***
		(0.0639)
L2.ROAA	–	−0.0552
		(0.0356)
Constant	−1.168	
	(1.728)	
Year dummies	Yes	Yes
Observations	1665	1215
R-squared	0.252	
No. of instruments		143
AR1 (p-value)		0.0228
AR2 (p-value)		0.230
Hansen-J (p-value)		0.267

Notes: Standard errors in parentheses * p < 0.10, ** p < 0.05, *** p < 0.010 denote the significance levels at 1, 5, and 10% risk levels, respectively. L.ROAA and L2.ROAA refer to one and two periods lagged values of the dependent variable. For other notations, see Table 1 notes.

Table 4
Effect of sovereign risk premium on ROAE – full sample.

	Model 3; Fixed Effect	Model 4; Two-step DGMM
	ROAE	ROAE
sovereign_risk	−2.720***	−4.207***
	(0.954)	(1.315)
sovereign_risk x before 2012	−4.617	0.100
	(3.082)	(1.276)
bank_size	1.797	11.32
	(3.221)	(7.824)
cap_adequacy	0.957**	3.555***
	(0.385)	(1.134)
cus_deposit	0.185***	0.209
	(0.0705)	(0.163)
liquidity	−0.182***	−0.109
	(0.0682)	(0.191)
cost_efficiency	−0.0674	−0.0813
	(0.0721)	(0.0654)
credit_risk	−0.284	−0.902**
	(0.299)	(0.377)
bank_div	−0.0745	−0.105
	(0.0779)	(0.0641)
L.ROAE		−0.201***
		(0.0722)
L2.ROAE		−0.0991**
		(0.0400)
Constant	6.919	
	(32.15)	
Year dummies	Yes	Yes
Observations	1663	1210
R-squared	0.221	
No. of instruments		140
AR1 (p-value)		0.0298
AR2 (p-value)		0.571
Hansen-J (p-value)		0.156

Notes: Standard errors in parentheses * p < 0.10, ** p < 0.05, *** p < 0.010 denote the significance levels at 1, 5, and 10% risk levels, respectively. L.ROAE and L2.ROAE refer to one and two periods lagged values of the dependent variable. For the other notations, see Table 1 notes.

Table 5
Effect of sovereign risk premium on RORWA – full sample.

	Model 5; Pooled-OLS	Model 6; Two-step DGMM
Regressors	RORWA	RORWA
sovereign_risk	32.93	−0.383**
	(33.12)	(0.151)
sovereign_risk x before 2012	−21.33	−0.373
	(25.11)	(0.302)
bank_size	−23.60	0.471
	(26.90)	(0.925)
cap_adequacy	55.94	0.698***
	(54.80)	(0.0759)
cus_deposit	−8.365	0.0256
	(8.260)	(0.0195)
liquidity	3.002	0.0127
	(3.548)	(0.0164)
cost_efficiency	−1.757	−0.00901
	(1.853)	(0.00870)
credit_risk	−7.118	−0.171***
	(7.025)	(0.0505)
bank_div	−1.911	−0.0102
	(2.014)	(0.00978)
L.RORWA		−0.267***
		(0.0892)
L2.RORWA		−0.0956
		(0.0611)
Constant	511.7	
	(551.5)	
Year dummies	Yes	Yes
Observations	1192	751
R-squared	0.0342	
No. of instruments		109
AR1 (p-value)		0.0941
AR2 (p-value)		0.806
Hansen-J (p-value)		0.459

Notes: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$ denote the significance levels at 1, 5, and 10% risk levels, respectively. L.RORWA and L2.RORWA refer to one and two periods lagged values of the dependent variable. For the other notations, see Table 1 notes.

words, this result suggests that the low and negative rate implementation has alleviated the tension caused by the ESDC discussed earlier in Section 2. Interestingly, in the case of non-GIIPS banks, ROAA reacts more strongly to the low and negative rate policy than in the case of GIIPS banks. There is no ample evidence proving that this effect would have strengthened or weakened during the financially distressed era (the coefficient of the interaction term in the case of the non-GIIPS is insignificant, see Appendix 5). Therefore, further analysis needs to be done to justify the publicly often heard claim that Northern banks (i.e., banks other than GIIPS) have paid extra costs for stricter regulations applied to the banking system in the euro area as a whole.

As seen from the results reported in Table 4, an increasing sovereign risk premium also drags banks' ROAE down, and to a larger extent compared to ROAA. Based on the DGMM- results, an increase of 1 percentage point in the sovereign risk premium generates a contraction of over 4 percentage points in the ROAE. This finding is in line with that of Bikker and Vervliet (2018) and Lopez et al. (2020), for the part when interpreting the sovereign risk premium to be in connection to lowering shadow rate (ceteris paribus), because in their results the decreasing short-term interest rates had a negative effect on ROAE. They also acknowledged that this effect is much stronger in the case of ROAE compared to the case of return on assets. In the subsample analyses reported in Appendix 4, similar to the case of ROAA, the sovereign risk premium has an influence on both bank size groups. Nonetheless, large banks experience an enormous change in ROAE, which is two times stronger than that of small banks (see Appendix 4). This evidence, in combination with the fact that ROAA of large banks is less affected by the sovereign risk premium than that of small banks, raises the concern that leverage has been either upsized or downsized with different scales in the two groups. Alessandri and Nelson (2015) found that in order to deter the fall in ROA from affecting ROE, banks increased financial leverage. This concern is beyond the scope of more detailed analysis in this paper; however, our evidence seems to support the idea that large banks downsize deposits more aggressively than small banks, and thus, the ROE of such banks deteriorates more than that of smaller banks in low and negative rate times.

In general, there are not many differences in the results based on the risk adjusted RORWA-profitability compared to those of other standard profitability measures. Although the Breusch and Pagan Lagrange multiplier test for random effect suggests the use of pooled OLS model for the risk-adjusted measure (see Appendix 3), none of the coefficients reach statistical significance in this model. However, when employing the DGMM estimation, the coefficient of sovereign risk premium on RORWA becomes statistically significant (see Table 5). Now an increase of 1 percentage point in the sovereign risk premium results in a drop of 38 basis points in RORWA. Notably, Hansen's overidentification test for the DGMM model estimated for the RORWA profitability obtains good results in terms of the validity of instruments. Regarding the subsample analysis reported in Appendixes 4 and 5, there is one point worth to mention. After the low and negative rate policy has been implemented, the sovereign risk premium seems to have affected less on RORWA in both the non-GIIPS and significant banks. This diminishing effect, however, improves in terms of the significance level. Before 2012, the sovereign risk premium changes bring about more than 100 basis-point declines in RORWA of non-GIIPS and significant banks at 10% significance level. Meanwhile, after 2012, this effect is weakened but gets to be more statistically significant (at 5% level, see Appendixes 4 and 5).

Table 6
Effect of sovereign risk premium on NIM – full sample.

	Model 7; Fixed Effects	Model 8; Two-step DGMM
Regressors	NIM	NIM
sovereign_risk	0.00380	0.0351*
	(0.0186)	(0.0203)
sovereign_risk x before 2012	0.0320	0.0847**
	(0.0232)	(0.0353)
bank_size	−0.000626	−0.423**
	(0.134)	(0.165)
cap_adequacy	0.0611***	−0.00147
	(0.0184)	(0.0127)
cus_deposit	0.0144***	0.0110***
	(0.00449)	(0.00299)
liquidity	0.00429	0.0119**
	(0.0116)	(0.00468)
cost_efficiency	−0.00465**	−0.00322
	(0.00230)	(0.00210)
credit_risk	0.00156	−0.00139
	(0.00325)	(0.00236)
bank_div	−0.00524**	−0.00355
	(0.00265)	(0.00236)
L.NIM		0.491***
		(0.0767)
L2.NIM		0.00809
		(0.0366)
Constant	1.230	
	(1.466)	
Year dummies	Yes	Yes
Observations	1796	1361
R-squared	0.268	
No. of instruments		137
AR1 (p-value)		0.000166
AR2 (p-value)		0.836
Hansen-J (*p*-value)		0.146

Notes: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$ denote the significance levels at 1, 5, and 10% risk levels, respectively. L.NIM and L2.NIM refer to one and two periods lagged values of the dependent variable. For the other notations, see Table 1 notes.

4.2. Impact of sovereign risk premium on NIM

The connection between the short-term interest rates and banks' net interest margin (NIM) is not straightforward. More specifically, as discussed earlier in Section 2.1, banks' profits are derived from the asset and maturity transformation process. In other words, banks lend long and borrow short, and the maturity of banks' loan portfolio usually clearly exceeds the average maturity of banks' deposits and other debts. Hence, when the interest rates fall, banks' funding cost reacts and reduces more rapidly than their interest income. As a result, the NIM rises and gradually declines because customers will either repay or renew the loans at a lower interest rate (Wheelock, 2016). Nevertheless, during negative interest rates, a large majority of studies have found that NIM is squeezed because the banks could not transfer the low and negative rates to the depositors (Bech & Malkhozov, 2016; Bikker & Vervliet, 2018; Claessens et al., 2018; Lopez et al., 2020).

Surprisingly, the results from Table 6 indicate a contradictory perspective: the NIM has slightly improved when the sovereign risk premium has increased, i.e., when the sovereign yield has increased and the shadow rate remained the same, or the shadow rate has decreased as the sovereign yield has stagnated (or the changes in both have occurred at the same time). Specifically, an increase of about 3–4 basis point in NIM is caused by higher sovereign risk premium under the low and negative rate periods. However, note that the effect is statistically significant only at 10% level in the case of DGMM results. Nevertheless, our finding is intriguing, given that the most recent prior literature mainly supports the hypothesis that the NIM has been compressed during the negative interest rate era. Our analyses reveal no statically significant results for this effect. One potential explanation for this contradictory result is that as the shadow rate is implicitly in connection to other market rates (e.g., EONIA mid-rate or Euribors), when it moves deeper into the negative zone, these market rates are also clearly negative. Therefore, despite not being able to pass on the low and negative interest rates to depositors, banks can still take advantage of the inexpensive (even negative cost) wholesale funding from the interbank market. When banks obtain new funding, the interest rate on this newly attained funding during the lending period is negative, so the average interest expenses are mitigated at least for this part. In other words, instead of being a cost item, this part of interest expenses (and hence, a constituent of NIM) is a return item, which improves the NIM of banks.

The rise in sovereign risk premium can also be caused by inflation in government bond yields, which is a sign of increment in the overall risk of the economy. In these circumstances, firms are more likely to run into financial problems, too. Hence, banks have to do more loan loss provisions, which actually leads to decreases in other profitability measures, because a change in ROAA is contributed by the change in NIM, net non-interest income, loan loss provision, and net other income. Hence, the increase in the sovereign risk premium might be in positive connection to the NIM but simultaneously have a negative effect on all other profitability indicators. Prior studies have shown that during the low and negative rates, banks in general take more risks (Aramonte et al., 2019; Bottero et al., 2019; Delis & Kouretas, 2011; Heider et al., 2019; Nucera et al., 2017), which drives the instability of the market as a whole. Therefore, the claim that the escalation of sovereign risk premium induces shrinkages of overall profitability measures but enhances NIM is rational. In addition, this claim would call for further analysis of how the sovereign risk premium affects for example the wholesale funding ratio and loan loss provision of banks, especially during the low and negative rate periods.

With respect to the subsample analysis, there is some inconsistency in the results between the two groups of banks (see Appendix 4). More specifically, the NIM of large banks marginally benefits from the increment of the sovereign risk premium. In contrast, smaller banks suffer losses from this. This result is in line with that of Molyneux et al. (2018), stating that the adverse impact of the negative interest rate is more prominent in small banks. Hence, it might well be the case that large banks are more able to exploit the advantage of the wholesale market-based funding mechanism, provide loans in the international markets, and hedge against the interest rate risk.

Table 7
Effect of sovereign risk premium on wholesale funding.

	Model 9; Fixed Effects	Model 10; Two-step DGMM
Regressors	wholesale_fund	wholesale_fund
sovereign_risk	0.139	0.297**
	(0.0893)	(0.134)
sovereign_risk x before 2012	0.440***	0.144
	(0.148)	(0.123)
bank_size	−1.132	−1.665*
	(1.117)	(0.991)
cap_adequacy	−0.598***	−0.564***
	(0.173)	(0.121)
cus_deposit	−1.099***	−1.097***
	(0.0495)	(0.0369)
liquidity	0.0222	0.0701***
	(0.0354)	(0.0232)
cost_efficiency	−0.000947	−0.000447
	(0.00710)	(0.00264)
credit_risk	−0.0156	−0.0483**
	(0.0283)	(0.0220)
bank_div	0.000709	−0.000232
	(0.00802)	(0.00297)
L.wholesale_fund		0.168***
		(0.0406)
Constant	111.2***	
	(11.13)	
Year dummies	Yes	Yes
Observations	1792	1495
R-squared	0.893	
No. of instruments		141
AR1 (p-value)		0.00145
AR2 (p-value)		0.337
Hansen-J (*p*-value)		0.213

Notes: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$ denote the significance levels at 1, 5, and 10% risk levels, respectively. L_wholesale_fund refers to one period lagged values of the dependent variable. For other notations, see Table 1 notes.Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$ denote the significance levels at 1, 5, and 10% risk levels, respectively. For other notations, see the Table 1 notes.

4.3. Robustness analysis: Effects on wholesale funding and loan loss provisions

The same estimation method will be applied for analysing the effects of sovereign risk premium on banks' wholesale funding and loan loss provisions. Based on the results reported in Tables 7 and 8 it is evident that both variables respond to the sovereign risk premium given the presence of low and negative interest rates. Wholesale funding, illustrated by the ratio of wholesale funding to total funding excluding derivatives, expands by 0.29 percentage points for a 1 percentage point rise the sovereign risk premium. Meanwhile, retail funding decreases during the sample period. This result affirms the hypothesis that banks reach out to wholesale funding in the interbank market during the low and negative rate regime. Notwithstanding that, further investigation needs to be done to see how much of the new, wholesale market-based funding (especially with negative interest rate) really goes to issuing new customer loans and how much is just used, for example, meeting the tightening liquidity requirements. However, our dataset does not enable this extension at the moment.

Regarding the loan loss provisions, the DGMM estimation results also suggest a positive relationship between the sovereign risk premium and this variable. A one percentage point increase in the sovereign risk premium prompts banks to put aside 0.26 percentage more loan loss provisions (see Table 8). Once again, this finding reinforces the claim

Table 8
Effect of sovereign risk premium on loan loss provisions.

	Model 11; Fixed Effects	Model 12; Two-step DGMM
Regressors	loss_provision	loss_provision
sovereign_risk	0.235***	0.266***
	(0.0625)	(0.0898)
sovereign_risk x before 2012	0.0983	0.132
	(0.110)	(0.124)
bank_size	−0.305*	−0.245
	(0.173)	(0.247)
cap_adequacy	−0.00845	−0.0504
	(0.0287)	(0.0445)
cus_deposit	−0.0142**	−0.0200***
	(0.00605)	(0.00679)
Liquidity	0.0137***	0.0215*
	(0.00429)	(0.0113)
cost_efficiency	0.00470	0.00664
	(0.00297)	(0.00450)
credit_risk	0.0302	0.0448**
	(0.0219)	(0.0213)
bank_div	0.00423*	0.00594
	(0.00247)	(0.00393)
L.loss_provision		0.0610
		(0.0543)
Constant	2.857	
	(1.811)	
Time dummies	Yes	Yes
Observations	1773	1465
R-squared	0.217	
No. of instruments		150
AR1 (p-value)		0.0256
AR2 (p-value)		0.178
Hansen-J (*p*-value)		0.112

Notes: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$ denote the significance levels at 1, 5, and 10% risk levels, respectively. L.loss_provision refers to one period lagged values of the dependent variable. For other notations, see Table 1 notes. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$ denote the significance levels at 1, 5, and 10% risk levels, respectively. For other notations, see the Table 1 notes.

that banks are obliged to tolerate more risks under low and negative rates, thus needing to allocate more for loan loss provisions, too. One intriguing point is that Angori et al. (2019) and Hanzlík and Teplý (2019) found a positive connection between loan loss reserves and NIM, owing to the fact that banks expose to more credit risk post crisis. Whether this is a single-way effect or a mutual one, it is worth investigating further if improvements in NIM are more than make up for loan loss provisions. For instance, if a bank is more attentive about NIM - the gauge of profitability sustainability, it would be more neglecting of the more general profitability measures, ROAA or ROAE as examples. With that being said, this robustness analysis does not aim to overclaim the hypotheses that have been proposed previously but adds moderately to the confidence in the previous results and opens up a new research direction on how the wholesale-based funding and loan loss provisions shift under the negative rate regime and how they contribute to the changes in bank profitability.

4.4. Further robustness analysis: Credit default swap spreads and bond yield spreads as alternative measures for the sovereign risk premium

To examine the robustness of our empirical results obtained using our suggested new measure for the sovereign risk premium, some further analyses were executed using 5-year credit default swap (CDS) spreads and bond yield spreads as alternative benchmarks for the measurement of sovereign risk premium.[6] The necessary country level CDS data were taken from the REFINITIV/EIKON Datastream. The new variables in the robustness tests were the CDS spreads, and alternatively, the bond yield spreads. The CDS spreads we calculated by subtracting the mid-spread of the European 5-year benchmark from the CDS mid-spread of each individual country for the 5-year sovereign bonds. Similarly, we subtracted the 10-year German bond yield, which serves as the representative of the risk-free yield for the whole Euro area, from the 10-year government bond yield of each member country to obtain the bond yield spread. In the robustness checks, the CDS spreads and bond yield spreads were used separately in place of our newly defined sovereign risk premium in the regression models. The empirical results from both cases are reported in the online Appendixes 6 and 7, but they can be summarized as follows.

For the case of using the bond yield spreads, their effects on banks' profitability are almost exactly in line with our original results using the shadow rate for the measurement of sovereign risk premium. In particular, the ROAA is negatively affected by the bond yield spread, and this effect is mitigated since the negative interest rate policy was promulgated in 2012. The bond yield spread has also a similar effect on the NIM development as the shadow rate-based sovereign risk premium. An obvious explanation for these similarities is that the bond yield spread, and our new sovereign risk premium are at least partly linked to each other, because in both cases the other core component is the country level government bond yield.

However, when using the CDS spread data in our regressions, there are a few intriguing points that are worth pointing out. First, the CDS spread affects ROAA in the same manner as the new introduced sovereign risk premium does. However, this effect has tremendously reduced since the inception of the low and negative interest rate policy. This reduction was more modest in the case when we used the new sovereign risk measure. Considering both the shadow rate and European level CDS mid-spreads as the efficient approximations of overall regional risk, in effect we measure only the country level risk in both cases when we either deduct the sovereign bond yield or the country level CDS rate from them. When such risk builds up, it seems that the CDS spread data reveal a somewhat harder hit, and probably a somewhat overestimated effect on the profitability of the banking sector. In view of this finding, the shadow rate might be considered more effective in depicting exactly the monetary policy stand during the unconventional monetary policy era characterized by clearly negative interest rates in nominal terms, because it captures all the relevant yield curve components into its calculation, and not just the CDS yield in question.

Second, the coefficients of CDS spread on ROAE for the period prior to 2012 are statistically significant in both the fixed effects and DGMM models, which is a major contrast to the case of using the new measure of sovereign risk premium. These results indicate that the CDS spread had a strong effect on the ROAE profitability prior to 2012, but it vanished during the NIRP. This result is very different from the previous result when we used the new measure for the sovereign risk premium, so during the NIRP the sovereign debt CDS market seems to have lost its relevance in affecting the bank profitability at all, when the return on average equity is used as the measure for profitability. Finally, the CDS spread has a negative impact on NIM, although this effect is not economically strong. On one hand, this result implies that during the prevailing unconventional monetary policy period, changes in the CDS spread might not have so big impact on NIM, which has traditionally been considered as the primary profit generator of banks. On the other hand, also these additional results highlight the pre-eminence of the shadow rate in reflecting the monetary policy stance and when remembering the fact that it is closely related to other market rates but serves as an "aggregated" version of all of them, it is not surprising that when we include the shadow rate into the empirical model, the development of NIM is slightly enhanced.

Our results are now in line with the very recent results of Soenen and Vander Vennet (2022), even though our perspective is towards bank profitability, whereas they focus on banks' default risk. Namely, they

[6] We thank an anonymous referee for this suggestion.

argue empirically, using almost the same period of observations for the Euro Area banks, that the effect of ECB monetary policy on bank default risk, captured by the bank CDS spreads, can be partly explained through the sovereign debt risk channel. They make a difference between the impact of monetary policy on banks through its direct channel and indirect channel that operates exactly through the sovereign risk effects. They show that the highly accommodative ECB policies have lowered the bank default risk, and these effects are stronger for the banks in peripheral countries of the Euro Area. Furthermore, the downward effect on bank default risk was especially pronounced in the 2012–2014 sovereign stress period, and they also show that the beneficial effect of ECB policy on lowering the bank default risk persists in the post-2014 era during which the ECB implemented its asset purchase program and other unconventional tools. And as we well know, this period has also been characterized by negative nominal interest rates, both at the money market, and in many cases also at longer maturities for the government bonds. Our results support these arguments indirectly, too, but we also find that in terms of the profitability of banks, the continuation of unconventional monetary policy actions still might be destructive at the end of the day for the bank profitability. In addition to our own findings of positive effects from bank capital adequacy on profitability (see the Tables 3–5, that support the findings of Soenen & Vander Vennet, 2022, too), this profitability based finding supports also their results, because as it has well been documented in the previous empirical literature, the capital soundness (and hence, low default risk) of a bank is usually in connection to low profitability, at least when the bank is growing fast, as have most of banks been doing during the analysed time period in our sample. Hence, these both sides of the 'coin' of unconventional monetary policy actions have to be carefully considered when the ECB formulates its near-term unconventional actions, and after the sooner or later eminent withdraw from those, also its conventional monetary policy actions, under the extremely tightening inflation pressures as we have now started to observe. This is really not an easy task to do.

4.5. Impact of bank-level characteristics on profitability

In general, the regression coefficients of bank-level characteristics have consistent signs as stated by the theory, regardless of the specification analysed in Tables 3–8. Capital adequacy has a positive effect on bank overall profitability measures (i.e., ROAA, ROAE, and RORWA). This impact remains statistically significant at 1% level in both the whole sample and subsample analyses reported in the Appendixes, too. In line with our a priori expectations, an increment in the capital would require higher profits since the cost of equity is always higher than the cost of debt. A one percentage point increment in capital ratio would seem to require 28 basis points higher values in ROAA. This impact is amplified in case of ROAE because of the connection between those two non-risk-adjusted indicators that was portrayed earlier, too. On the other hand, a growth of 70 basis points in RORWA is required to compensate for the higher equity costs. Another factor that has persistent impacts on bank profitability is the credit risk, measured by the ratio of non-performing loans to gross loans. In contrast to the capital ratio, the credit risk adversely affects banks' profits, as expected.

The amounts of deposits and liquid assets both stimulate NIM but in different degrees. Bigger banks seem to rely more on deposits. Meanwhile, smaller banks are more responsive to the balance of cash and reserves at central banks. Despite being statistically significant, these effects are economically small, creating approximately 1 to 3 basis points change in the NIM. Another point worth noticing is that the smaller banks are more sensitive to the cost efficiency and bank diversification. The expansion of operating expenses will slightly hurt the NIM. Other activities apart from the core banking business will drive small banks' NIM away with the same adverse impact. Many previous studies have emphasized the position that gains in non-interest income offset banks' losses from traditional activities during the low and negative rate era (Altavilla et al., 2018; Lopez et al., 2020). This analysis attempts to estimate the impact of the sovereign risk premium on bank diversification (or non-interest income streams). It is confirmed that during such an era, banks diversify more sharply.

5. Conclusions

In order to analyse the bank profitability effects of the low and negative interest rates era and sovereign risk premium in a novel way, we have utilized many panel econometric methods on a dataset including 154 banks from the Eurozone for the period from 2005 to 2019. One of the main new innovations in our analysis was to introduce a completely newly defined measure for the sovereign risk premium to the empirical analysis. In this study this premium was measured based on calculating the spread between the country-level government bond yields and the ECB shadow interest rate, which is the same for every individual country in the euro area in a given time period. The shadow rate itself has been previously considered to be an efficient approximation for monetary policy stance. The newly defined sovereign risk premium was expected to reveal the required sovereign risk premium of each Eurozone country, where banks reside, in excess of the common monetary policy rate.

Our main results can be summarized as follows. First, the sovereign risk premium has a robust and clear negative impact on both the non-risk-adjusted and risk-adjusted bank profitability indicators, but the effect varies e.g., between the significant (big) and non-significant (small) banks in the euro area. However, in general terms, there is no difference between the results based on the standard and risk-weighted profitability indicators. In most cases, depending on the optimal estimation method, we find that the effect was not statistically significant prior to the introduction of QE measures and negative interest rates in 2013. To a certain extent, we can infer from this that if NIRP is prolonged and the nominal interest rates go even more deeply negative, the Eurozone banking sector faces serious profitability problems. This is in line with IMF (2016), stating that even though sometimes strong interest rate cuts are required in the aftermath of crises, from a longer- term point of view, the extremely low and negative interest rates will cause a deterioration in the bank profitability in general terms, too.

In practise, based on our definition of the sovereign risk premium, an increase in it means that either the government bond yield rises, or the shadow rate declines, or both take place simultaneously. In economic terms, our results actually indicate that the ECB might be more or less forced to continue its extremely low-rate policies, and intervene also in the government bond markets very actively at least in the near future, because a widening sovereign risk premium especially based on the increases in the government bond yields (induced by lowering prices of the bonds)[7] would have a strong negative effect on the bank profitability in the euro area. This introduces a clear dilemma for the future monetary policy actions. Namely, if the ECB would allow the bond yields to rise, while it maintains the real activity boosting negative short-term rate policies, both these actually seem to have a negative effect on the bank profitability in a longer-term perspective. Hence, one of our biggest new policy implications based on the analysis of recent data from the euro area banks is, that the ECB should start to gradually withdraw its strong asset buying programs and let especially the short-term interest rates start to gradually rise towards even positive side. In the circumstances of positive yield curve slopes, the long-term interest rate would also start to

[7] Note that if the central bank reduces its buying activity from this bond market segment, and hence, the prices decrease, ceteris paribus, the (required/expected) yields increase and the sovereign risk premium increases, even without lowering of the shadow interest rate. This introduces a clear practical problem to all the central banks heavily involved with government bond markets, when trying to return back to the more 'normal activities' reflected by not involving too heavy positions in government bond holdings.

gradually rise, assuming that the ECB would not intervene as heavily in the longer maturity asset markets in the future. However, as long as the short-term rates increase more than the long-term bond market yields, the sovereign risk premium decreases, and according to our results, this will improve the bank profitability, too.

Now that the inflation pressures are clearly emerging also in the euro area due to the strong and fast recovery of the real economy after the COVID-19 crisis, and also due to the serious problems and price pressurs in e.g. the energy sector, this should actually be the natural path to be followed in the near future. Hence, the bank profitability development from a longer-term perspective would also be rescued if the central bank has the courage to let the interest rates gradually recover to their more normal paths through-out the whole maturity spectrum. Leaving aside the currently observed extremely good news about bank profitability at the doorstep of the real economic recovery from the pandemic crisis, our main results indicate that banks would still suffer losses in overall profitability if the unconventionally expansive monetary policy shocks would take place too long in the economy. This is consistent with some earlier studies (Borio et al., 2017; Molyneux et al., 2018), but none of these previous studies have focused on using the shadow rate data in the analyses.

In general, our findings obviously call for more research on how much for example interbank funding has been raised to facilitate new loans and how much of it has been for liquidity requirements. Further research should also be carried out to see whether the benefits from the low-priced interbank funding are offset by extra costs caused by a higher ratio of loan loss provisions. Now that in the most recent data we have seen that, at least based on the short-term quarterly figures from 2020 to 2021, the euro area banks have actually been able to recover very well from the COVID-19 shocks in terms of increasing their profitability, one of the propositions that our results introduce is that the ECB should start seriously considering a withdraw from its unconventional monetary policy actions, and not the least to be able to fight effectively against the currently tremendously increasing inflation pressures. According to our results, this would clearly further enhance the profitability of euro area banking sector, too. The main problem in this evidently necessary action is the current extremely heavy involvement of the central banks in the government bond markets, so this will clearly be a very difficult task to do.

CRediT authorship contribution statement

Juha Junttila: Conceptualization, Data curation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. **Vo Cao Sang Nguyen:** Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing.

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Appendix A. Supplementary data

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