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The Adverse Side-Effects of Negative Interest Rate Policies on Banking Stability

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Abstract

The purpose of this paper is to investigate banking stability in countries where Negative Interest Rate Policies (NIRPs) are implemented, then study this stability by examining the relationships between policy interest rates and indicators of not only banking profitability but also capital adequacy, asset quality, and liquidity. The dataset used are the Financial Soundness Indicators (FSIs) collected by the IMF, which are mainly used for measuring the economic stability among countries. A different panel regression is applied for each indicator, which includes policy interest rates as explanatory variables, and inflation and GDP growth rates as control variables. There are several statistical techniques which are implemented in this paper; however, a Two-Stage Least Squares (2SLS) regression is applied as a main method to estimate coefficients. Generally, this paper has shown some evidence that NIRPs have adverse side-effects on banking stability. Banking capital adequacy level and profitability both have a same trend with negative policy interest rate, in which under NIRP, capital adequacy and profitability levels are deteriorated.

Keywords: Banking stability, Negative Interest Rate Policy (NIRP), Financial Soundness Indicators (FSIs), Panel Regression

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1. Introduction

The 2008 global financial crisis has changed the way the central banks implemented monetary policies for regulating the economies. Following the crisis, the advanced economies' central banks kept cutting the policy rate until the short-term rate approached nearly the zero bound, which was curbed to be reduced further. With a rising concern about deflation, there were some central banks that announced to undertake unconventional monetary policies. In July 2012, the National Bank of Denmark applied an unusual policy rate which had not happened before in history: negative interest rates. And Denmark was not the only one: the European Central Bank (ECB) has also implemented a negative interest rate policy (NIRP) in 2014. Following this trend, other European countries adopted negative policy interest rates: Switzerland and Sweden in 2015, which were followed by Japan in 2016.

The reason for adapting a negative rate policy differed among central banks. For the ECB, Japan, Sweden and Switzerland, the priority was increasing inflation – which was very low after the worldwide crisis – while Denmark's main target was defending its currency peg scheme. IMF reports have shown that the countries got close to reaching their inflation goals, whereas the Eurozone's, Japan's, Sweden's and Switzerland's inflation rate was 1.3%, 1.1%, 2% and 0.8%, respectively by 2018 (Dell'Ariccia, et al., 2017). However, the negative rate also raised concerns about cash hoarding, decreases in banks´ interest margins, and deterioration in banks' profitability. The IMF publication reported that no signs of cash hoarding were detected during the period under NIRPs, which could mean that the negative policy rate might not have been transmitted completely to retail rates (Dell'Ariccia, et al., 2017). At the same time, the interest margins were slight lower in the Eurozone and Japan and remained stable in Demark and Sweden, while they increased slightly in Switzerland. In general, the research by the IMF has revealed no significant negative impacts to banks' profitability in these countries. In the Eurozone, lower interest margins were compensated by higher amount of lending loans, fees and lower provisions. This lines up with the consensus, that these unconventional policy interest rates so far have only had limited impact on the banking sector's profitability. However, research has also shown that banks in negative interest rate countries have lower profitability in general.

Yet, we believe that research in this topic so far have been limited by being one-dimensional and only focusing on banking profitability which is only one part of stability. Empirical analyses previously have missed other factors such as liquidity, asset quality, and capital adequacy, and only involved them theoretically. It is essential to further evaluate the stability,

because under a stable banking environment profits of the banks will be sustained in the long-term period, which is beneficial for the whole economy.

We measure banking stability with the International Monetary Fund's (IMF) indicator package named Financial Soundness Indicators (FSIs), which have 12 core indicators that are classified into five selective groups to deal with capital adequacy, asset quality, earnings and profitability, liquidity, and sensitivity to market risk. By analysing these indicators, the situation of financial institutions in a country will be uncovered. We use these indicators in regressions with policy interest rates to try to answer our research question, whether negative interest rate policies (NIRPs) have adverse side-effects on banking stability. We apply 2SLS technique as a main method for estimating under panel regressions in which FSIs are dependent variables and policy rates are used as the explanatory variables. Since we know the that central banks have implemented negative interest rates to reach specific economic targets – such as inflation –, we can imply that the state of banking stability has no influence on central banks´ decisions to implement Negative Interest Rate Policies. This is supported by the Taylor rule which says that policy interest rate decisions are based on inflation and GDP. This is important because if we find a statistically significant relationship between the indicators and interest rates from the regressions, we can imply causality thus answering our research question.

Overall, our analysis provided some evidence for the detrimental side-effects of NIRPs on banking stability. The results indicated that this effect mainly manifested in form of declining capital adequacy and lower profitability. Additionally, there is also some concern regarding asset quality for banks in negative interest rate countries – shown by the high proportion of nonperforming loans (NPLs) – although our results did not indicate any relationship between them and interest rates. Finally, our results showed no sign of any effect on liquidity.

In chapter 2, we will present the underlying theories behind our thesis. These theories include an introduction to Negative Interest Rate Policies (NIRPs), financial stability, and we also show the results of previous research in this topic. In chapter 3, we outline the methodology we use to analyse our data. Chapter 4 includes the empirical results of our statistical analysis, with chapter 5 discussing our results under the backdrop of the theoretical predictions. Finally, in chapter 6 we give our conclusions based on our research and present the limitations.

2. Theory

In this chapter, we will present the underlying concepts and theories that should be understood to be able to fully comprehend the conclusions of our research. First, a general outline of interest rates is introduced and discussed in section 2.1, with a focus on policy interest rates. In section 2.2, we introduce the Taylor rule, which is the backbone theory for implementing policy rate in monetary policy. This is followed by the detailed description of Negative Interest Rate Policies (NIRPs) in section 2.3, and the reasons why central banks implement them. Section 2.4 describes what banking stability is and how it is measured and controlled by the Basel Committee. Section 2.5 introduces the Financial Soundness Indicators (FSIs), which is followed by the relevant theories on how NIRPs can adversely affect banking stability in section 2.6. Finally, in section 2.7, we present the important results of previous research in this subject.

2.1. Interest rates

There are many different definitions of interest rates. In general, interest rates are defined as the amount of money that a borrower is obliged to pay for using a loan under the term of percentage (Marshall, 1890, p. 50). Another interpretation is given by John Stuart Mill (1885), in which interest is the remuneration in the future for benefits sacrificed in the recent. For more modern definitions, Keynes (1936) described interest rate as "…the reward for parting with liquidity for a specified period". However, for perceiving a homogeneous definition, interest rates should be interpreted under terms of capacity, saving, liquidity and monetary value. More specifically, interest is the annual compensation for the capital return, income of saving, loss of the current liquidity and the money funding. In this paper, policy interest rate is in the focus of the research because of its application and its influence to the whole economy.

2.1.1. Types of interest rates

There are several different types of interest rates that exist in a single economy, which poses a problem when researching the effect of interest rates. Interest rates are classified into several categories based on their characteristics. Generally, interest rates can be divided to nominal interest rates and real interest rates. The difference between them is that the inflation is taken into account for calculating real rates while nominal rates do not use inflation (Croushore, 2007). Inside nominal interest rates, several groups of interest rates are further classified based on the following aspects: the institution offering the credit, the time length of the loan,

the flexibility of the contract. For the first aspect, in agreements between financial institutions, lending and borrowing rates are represented by different terms such as: discount rates, repurchase agreement (REPO) rates, and overnight rates (Madura, 2008). Meanwhile, between banks and customers, these rates are quoted as retail interest rates (e.g. credit rates, mortgage rates, deposit rates, saving rates, etc.). According to the second aspect, interest rates are differentiated by the length of the loan to long-term interest rates and short-term interest rates. The third aspect, flexibility characterises loans as either fixed interest rate loans or floating interest rate loans. In a fixed interest rate loan, interest payments are constant during the period of a loan, while in a floating rate loan the payments change periodically based on various underlying factors (Coyle, 2001).

This thesis is researching policy interest rates, which is the interest rate applied between the Central Bank and other institutions. The policy rate is adopted as a mechanism of a country's monetary policy to regulate money supply which then directly impacts the whole economy. Because of the policy rate's important role in supporting the whole economy, we argue it might also have effects on the stability of the financial sector, especially the banking sector.

2.1.2. Policy interest rates

Generally, a situation of expansionary or contractionary monetary policy is decided with decreasing or increasing the policy rate. To simplify the definition of policy rate, commercial banks could borrow from the Central Bank at the policy interest rate, except for some countries focusing on overnight rate such as Canada (Handa, 2009). When the rate is lower, there is an obviously incentive for commercial banks for borrowing and then the money is supplied to the market. In contrast, under higher rates the banks would intend to reduce their loans from the Central Bank and would use other sources instead. Consequently, the money is withdrawn from the market.

However, different countries apply different types of policy rates. The three most common types of implemented policy rates are: overnight lending rate (Canada, Switzerland, etc.), discount rate (United States), and repurchase agreement (REPO) rate (Sweden). The overnight lending rate operates in the overnight market where a depository institution lends or borrows funds from another one (Handa, 2009). Because it is only available for only the most creditworthy institutions, overnight rate always is set as the lowest one among available interest rates. The discount rate is more related to the Central Bank debt instruments (e.g.: bonds, bills). The Central Bank issues debt instruments to commercial banks with a discount at discount rate or accepts the rate to lend a financial institution (usually a bank) which is

using government securities as collateral (Gibson, 2003). The REPO rate is related to temporarily transferring the title of government securities between Central Bank and financial institutions in which the Central Bank promises to buy them back in the short-term period at the REPO rate (Choudhry, 2010). Similarly to discount rate – although they seem like an ordinary selling or purchasing of financial contracts – financial institutions are borrowing or lending collateral-backed funds from the Central Bank.

2.2. Taylor rule

The Taylor rule is considered one of the most important backbone theories in researching applied policy interest rates. It was considered as a revolution in the way that policy makers determine the monetary policy at central banks. Instead of targeting to ranges of the monetary aggregates, they started implementing policy interest rate as a monetary policy's instrument (Asso & Kahn, 2010). The theory describes a relationship between the nominal interest rate (issued by central banks) and two main economy indicators: a discrepancy of actual gross domestic products from the potential one (GDP gap) and the inflation rate (Taylor, 1993). The equation can be represented as:

$$i_t = \pi_t + a_y * y_t + a_\pi * (\pi_t - \pi_t^*) + r_t^*$$

In which, i_t is used as notation of policy interest rate, y_t represents difference percentage between real GDP and the potential GDP, π_t is inflation rate during preceding four quarters, π_t^* is the desired rate of inflation and it is usually set at 2%, and r_t^* is the equilibrium interest rate, which is also usually assumed to be 2%. In the equation a_y and a_π are originally set to be equal to 0.5 by Taylor (1993). According to this formula, the implemented policy rate not only needs to increase, but also has to rise more than one for one compared with the inflation. There were several reasons that Taylor rule was accepted broadly at the time it was written. According to the published paper, the results illustrated the rule kept track on the real federal fund rate of United States' trails during period 1987-1992 (Taylor, 1993). Since setting equal weights on both GDP gaps' percentage and the inflation's fluctuation from its target, Taylor rule was also applied for a regime that was targeting both price stabilization and economy expansion (Asso & Kahn, 2010, p. 10). Finally, Taylor rule did not invoke the rule of the recent systematic policy at this time, these statements were expressed that "…there will be episodes where monetary policy will need to be adjusted to deal with special factors" and "…it is important to preserve the concept of a policy rule even in an environment where it is practically impossible to follow mechanically the algebraic formulas…" (Taylor, 1993, p.

197). For these reasons, the Taylor rule became prominent and was applied widely among central banks.

2.3. Negative Interest Rate Polices (NIRPs)

For a long time, the Central Banks did not accept a scenario in which policy rate could drop below zero. A zero-bound interest rate was considered as a natural limit, where both corporations' and individuals' cash would remain in bank accounts. According to this theory, if a negative deposit interest rate was in use, account holders would withdraw cash to prevent value reduction. This phenomenon is known as cash hoarding. Consequently, instead of receiving benefits of negative rate, banks would only receive zero nominal income, which would result in limited lending volumes. In this scenario, the central bank would fail to control interest rates when setting the policy rate below zero percent, thus creating the zero lower-bound (ZLB).

Since the financial recession however, there has been a noticeable trend that natural interest rates keep going down, while the inflation remains at a low level. A new standard emerged which features a lower natural real interest rate. The definition of natural real interest rate was introduced by Knut Wicksell (1898), which is that the natural rate would be revealed when both the economy's output met its potential and the inflation rate reached its target. For implementing expansionary (contractionary) monetary policy, the policy rate must be adopted below (above) the natural one. At a low level of inflation and decreasing trend of natural rate, extremely low policy interest rate may be applied for increasing inflation. The Federal Reserve Bank of San Francisco has found that the declining trend of natural interest rate happened in many areas and countries: Canada, Eurozone, United Kingdom and United State (Holston, et al., 2016). Moreover, the working paper conducted by Federal Reserve Bank of Dallas shows that during period 1961-2015 "…both the world natural interest rate and the trend potential output growth rate have been declining significantly in the past fifty years." (Wynne & Zhang, 2017). Consequently, negative interest rate policy (NIRPs) now becomes easier to be adopted under central banks' monetary policy.

Under the environment of low inflation and decreasing equilibrium of natural rate, it might be considered necessary to remove zero lower bound (ZLB) for the policy rate. The purpose of moving the policy rate into negative territories is that expected inflation could be improved and then support to recover aggregate demand of the whole economy (Jobst & Lin, 2016). In other words, instead of depositing money to the Central Bank, the Central Bank encourages

the banks to create more loans on households, corporates and other banks, so that economy will be boosted (Das, 2015).

In practice, many different goals were set when countries applied NIRPs. Almost all countries (Euro Area, Japan, Sweden and Switzerland) implemented NIRPs as a mechanism to reach inflation target. There was only Demark that only used the policy to protect its peg exchange rate scheme. However, the monetary policy cannot solve the problem by itself. The central bank would face some risks when implementing the below-zero policy interest rate. Commercial banks could be hesitant to reduce the deposit rates because of the cash hoarding phenomenon. While reducing their lending rate, it could also have to an adverse impact on banks' profitability. Furthermore, banks would intend to increase their loan interest rate to compensate for the costs of adopting non-negative deposit rate for wholesale clients while the funding costs are declining, but competitive pressure prevents them, resulting in narrowing interest margins (International Monetary Fund, 2006). Generally, the transmission from policy rate to lending rate would be less effective than its initial aim. This is the reason why the negative interest rate countries adopted many instruments other than the negative policy rate. Each economy supplemented their special tools, such as asset purchasing (Both Eurozone and Sweden), targeted long-term refinancing operations (Euro zone), quantitative easing and yield controlling (Japan), and foreign exchange intervention (Denmark and Switzerland).

There were clear results showing, that by implementing NIRPs as one of regulating tools, the countries achieved their stated goals. The Eurozone´s, Japan´s, Sweden´s, and Switzerland's inflation rate reached 1.3%, 1.1%, 2% and 0.8% in March 2018, respectively. In Demark, the appreciation of Denmark krona was mitigated. In Switzerland, other than the prevented deflation, appreciation pressure has also eased. In the Eurozone credit difficulties were reduced and positive loan growth rate appeared while medium-term inflation projection increased slightly since the countries applied NIRPs.

The targets were not solely impacted by NIRPs because each country also supplemented other tools under their monetary policy, but it is safe to say that NIRPs contributed at least in part to the success of the monetary policy.

2.4. Basel regulation

After understanding the basics of interest rates and NIRPs, another important issue regarding this topic is banking stability and how we can measure it. The two key subjects regarding banking stability are the Basel Accords issued by the Basel Committee on Banking Supervision and the Financial Soundness Indicators developed by the IMF. The Basel

Committee Accords are vital regarding this thesis because the data used are the Financial Soundness Indicators (FSI) – developed by the IMF – which are based on the Basel Accords, mainly Basel III.

2.4.1. Basel Accords

The issue of banking stability has always been a key problem in modern economies. This is the reason why the Basel Committee was established in 1974 by the G10 countries following some serious disturbances in the international currency and banking markets (Bank for International Settlements, 2016). Since its establishment, the Basel Committee has expanded to include 45 members and now serves the goal of enhancing financial stability worldwide. Over time the Basel Committee has issued three supervisory agreements called Basel Accords, which are technical recommendations on banking laws and regulations. Basel I, also known as 1988 Basel Accord was issued in 1988 with the primary focus on capital adequacy and credit risk. The Accord called for minimum capital to risk weighted assets of 8% to be implemented, and it was accepted by the nearly all countries not just the member countries (Bank for International Settlements, 2016).

Basel II was published in 2004 to replace the 1988 Accord, and included a much wider range of issues which were organized in three pillars. The first pillar of Basel II – minimum capital requirements – gives recommendations on how banks should deal with credit risk, operational risk, and market risk. The second pillar – supervisory review – gives the regulators improved mechanisms to oversee banking stability and also includes residual risks. Finally, the third pillar – market discipline – develops a set of disclosure requirements for market participants. The implementation of Basel II was slow over the world and it was also hindered by the global financial crisis with some claiming that the regulation even increased the effect of the crisis (Slovik, 2012). This crisis, however, displayed the need to strengthen and rework the Basel II framework, thus the Basel Committee began designing a new Accord called Basel III. Basel III was agreed upon by the Basel Committee members in 2010-11 and it is scheduled to be implemented by 2019. The Basel III framework is currently the most extensive blueprint on banking stability that includes specific requirements on capital adequacy, leverage ratios, and liquidity requirements amongst several destabilizing risk factors affecting banks (Basel Committee on Banking Supervision, 2017). The structure of Basel III is based on the same three pillars as Basel II with the pillars strengthened.

2.5. Financial Soundness Indicators (FSI)

The FSI indicators "are indicators of the current financial health and soundness of the financial institutions in a country, and of their corporate and household counterparts" (International Monetary Fund, 2006). The indicators are grouped to deposit takers, other financial corporations, non-financial corporations, households, market liquidity, and real estate markets, and consist of 39 different indicators. In this thesis, the relevant ones are the indicators for deposit takers which are also grouped into Core FSIs and Encouraged FSIs. Each indicator is a ratio, therefore comparison between banks or countries is simple, although individual interpretation is sometimes difficult, since some of the indicators are only meaningful in combination with other indicators, especially on an aggregate level.

Table 1 shows the 12 Core FSIs for deposit takers, which deal with capital adequacy, asset quality, earnings and profitability, liquidity, and sensitivity to market risk. These five groups are often shortened in the acronym CAMELS, as they are used in the CAMELS rating system, which is mainly used the U.S.

Table 1 : Financial Soundness Indicators (FSIs)

FINANCIAL SOUNDNESS INDICATORS: THE CORE SET

Capital adequacy	Regulatory capital to risk-weighted assets
	Regulatory Tier 1 capital to risk-weighted assets
	Nonperforming loans net of provisions to capital
	Capital to assets*
Asset quality	Nonperforming loans to total gross loans
	Sectoral distribution of loans to total loans
Earnings and profitability	Return on assets
	Return on equity
	Interest margin to gross income
	Noninterest expenses to gross income
Liquidity	Liquid assets to total assets (liquid asset ratio)
	Liquid assets to short-term liabilities
Sensitivity to market risk	Net open position in foreign exchange to capital

** Capital to assets is normally included in Encouraged Set, we use it for Capital Adequacy*

2.5.1. CAMELS rating

The CAMELS rating system was developed by the Uniform Financial Institutions Rating System in 1979 and it uses the same factors as the IMF Financial Soundness Indicators, namely capital adequacy, asset quality, management, earnings, liquidity, and sensitivity to market risk (Lopez, 1999). Each bank is rated on a 1-5 scale (1 being the best) on each category and then each category is given a weight to create the CAMELS composite rating. These ratings are not publicly available data (Shaw, 2016). Regarding this research, it would have been possible to construct a single rating from the available FSIs, however the loss of information would have been more problematic than it would be useful to use a single composite value for each country. Even if the centrally computed CAMELS rating numbers were available, there are compelling reasons to use the individual indicators, which allow us to study banking stability more thoroughly.

2.5. Financial Soundness Indicators (FSI) (continued)

In the Core indicator set for FSIs, capital adequacy is measured by three different indicators, which are regulatory capital to risk-weighted assets, regulatory Tier 1 capital to risk-weighted assets, and nonperforming loans net of provisions to capital. The first two are both the same as the minimum capital requirement measures set out by the Basel II, where Tier 1 capital is a narrower measure of capital adequacy. The third indicator measures capital adequacy by looking at the potential impact of nonperforming loans on capital, which can show the capability of the bank to withstand NPL-related losses.

Asset quality is only measured by two indicators, nonperforming loans to gross loans and sectoral distribution of loans to total loans. The former is used to spot problems with asset quality in the loan portfolio, while the latter provides information on the distribution of the loans to resident and non-resident sectors. A large concentration in one sector could be vulnerability for the deposit takers.

Earnings and profitability is the largest group, measured by four different Core indicators: return on assets, return on equity, interest margin to gross income, and noninterest expenses to gross income. Return on assets measures the efficiency of banks in using their assets and is often used in combination with return on equity, which measures the efficiency in using capital. These two in combination can give key information about sustainability over time. Interest margin to gross income measures “the relative share of net interest earnings – interest earned less interest expenses – within gross income” (International Monetary Fund, 2006), For this thesis, this is a very important indicator, as we expect lower interest rates to affect

interest margins primarily. Finally, noninterest expenses to gross income looks at the size of administrative expenses compared to gross income.

Liquidity is measured by liquid assets to total assets, and liquid assets to short-term liabilities. The former is also called liquid asset ratio, and it measures the capability of deposit-takers to meet expected and unexpected demand for cash. The latter indicator, on the other hand, shows the capacity of deposit-takers to meet short term withdrawal of funds with their liquidity. This for example is crucial when bad news about markets are emerging, such as at the early days of the global financial crisis.

In this thesis, we used these Financial Soundness Indicators as the measure of financial stability and further description of the data will be provided in section 4.1 for each indicator. However, there are more indicators for deposit takers provided by the IMF.

The Encouraged Financial Soundness Indicators for deposit takers include further 14 indicators which are less useful, less relevant, or possibly less available than the Core indicators, however they can still show some interesting results thus they are considered 'encouraged' to be used by the IMF. Such indicator for example is large exposures to capital, which was originally in the Core indicators and was moved to the Encouraged set in 2004 (International Monetary Fund, 2006, p. 3). Other than this, some important indicators here are indicators measuring positions in financial derivatives to capital, and capital to assets (financial leverage). Finally, one possibly relevant indicator for this thesis is the spread between reference lending and deposit rates.

2.6. Negative effects on banks

In this section, we outline the backbone theories of our thesis, which are the potential mechanisms in which negative interest rates – or more specifically NIRPs – may adversely affect the stability of the banking sector in a given economy. Due to the nature of the data, in this thesis we investigate effects on deposit takers, which is equivalent to banks for our purposes. It is important to note, however, that negative interest rates have effects on other financial intermediaries, not just banks.

As it was mentioned before, the goal of NIRPs is to reach certain macroeconomic objectives, but it could certainly have negative side effects for banks, mainly by affecting interest margins. Previous research has already confirmed that there is a long-run positive relationship between bank profitability and interest rates, which means that banking profitability could suffer with decreasing interest rates (Turk, 2016). According to research, decreased profitability is caused mainly by the decreased interest margins for banks, which is the main

way banks make profit from deposits and loans. The underlying process behind the narrowing interest margins is, that banks do not want to charge a negative interest on the deposits of their customers – with the fear that it may lose them clients – but at the same time they are pressured to lower their lending rates by competitor banks.

Parallel to the lower interest margins however, demand for loans naturally increases, which in theory should balance out the losses by the banks either through lending volumes or possible fees implemented to make up for the losses. Additionally, low interest rates generally result in increased bond prices which also give banks extra income. Whether these mechanisms really balance out the profitability of banks in negative interest rate environments is up to further research.

An issue with the increased demand for money is that very low interest rates remove the profitability constraint of investments and increase indebtedness, which could be a problem not only for the banks but the whole economy. If there is no pressure on borrowers to make profits to pay off the interests on the loans, it could lead to increased ratio of nonperforming loans in the loan portfolio and increased credit risk in the economy. Additionally, the increased demand for cash combined with the low profitability could also lead to lower capital levels for the banks under NIRPs. These factors are already troubling under normal economic circumstances, but an eventual economic downturn could be magnified by them.

The European Central Bank – which also has negative deposit rate – in their Euro area bank lending survey of the third quarter of 2017 reports the results of an ad hoc survey questionnaire. The results show that Eurozone banks are claiming that the negative interest rates have negative effects on their net interest income, and also have negative impact on their lending rates, as well as negative impact on their loan margins in the period (European Central Bank, 2017). In the 2017 Q3 report, they also reported that the increase in non-interest charges (fees) on loans was close to zero, indicating that the level of fees has reached a stable point after increasing in the previous periods, which was shown by previous reports. On the other hand, the banks continued to report a positive effect on their lending volumes, which in a system more reliant on fees could provide the missing profits to the banks. Again, this confirms that banking stability is adversely affected by NIRPs mainly by lost profits from interests.

Another possible negative effect that is worth noting is due to the downward stickiness – meaning resistance to downward movement – of deposit rates, which might also raise financial stability concerns for banks. Jobst and Lin argue that this effect might “encourage banks to substitute less stable wholesale funding for deposits”, which could jeopardize

liquidity (Jobst & Lin, 2016). This theory is in line with the theories shown above but the authors also link it to liquidity, which is another measure of bank stability that could be affected.

Finally, the shift to exceedingly complicated financial instruments caused by unconventional policies, and changing investment portfolios employed by banks could be affected by negative interest rates in unanticipated ways. The theories above are not always successful in modelling reality, so in the same line there could be economic and financial mechanisms emerging due to NIRPs that might not even manifest in the current economic circumstances. The effects of unconventional fiscal policies have to be continuously studied for any sign of instability, since those might be the cause of the next financial crash.

2.7. Previous research

There have been several previous research papers done on the effects of negative interest rates from different perspectives, most of them concentrating on the Eurozone where deposit interest rates have been negative since June 2014. In this part, we will summarize the relevant results gathered by those studies.

An important result confirmed by research is that the negative policy rates have been converted into lower lending rates for both corporates and households. This is very important, since otherwise there would be no point in researching the effect of NIRPs. In Denmark and Sweden banks have also "passed negative rates to deposits of some large corporations and institutional investors but maintained positive rates for retail investors" (Jobst & Lin, 2016, p. 17). This shows that banks have already crossed the Zero Lower Bound (ZLB) for some of their customers, effectively showing that this bound is not as strict as it was suspected previously and might actually be lower than zero.

Since negative interest rates are not passed onto deposit rates for the public, there has been no decline in currency circulation, or no cash hoarding in other words (Cœuré, 2016). This means that the ECB has not yet reached the lower bound of interest rates where it is not worth for the people to put their money in the bank. The same study also noted that regulators should be mindful of the cumulative effects of NIRPs over an extended period of time, as it could adversely affect financial stability. The conclusion of Cœuré´s (2016) analysis is that banks should adapt to the changing environment and cut their operating costs and non-performing loans to improve their resilience, essentially suggesting that regulators are not responsible for the profitability of banks.

Gros et al. (2016) also notes, that NIRPs in the Eurozone could potentially increase risks in the banking sector and cause financial instability by "encouraging banks to substitute safe assets by riskier assets" and by "granting credit to ex-ante non-solvent agents", thus increasing the – already high – ratio of nonperforming loans. Their empirical results give limited support to these theories, as they note: "banks have provisioned to non-performing loans and compensated for falling interest rates by raising fees". It is important to note, however, that Eurozone banks have had a historical problem with NPLs and even the inability to substantially decrease them could be an effect of NIRPs (Comfort, et al., 2018).

Danthine´s (2017) research adds that the effect of NIRPs – at least in Switzerland – have been asymmetric; meaning that transmission of policies through the banking system did not operate in the same manner as above zero percent interest rates. This results in the inconsistent results for providing monetary stimulus to the economy, with no increased lending rates or mortgage rates. Danthine (2017) offers that either further reduction in interest rates might be necessary or returning to zero interest rates, but further reduction is unlikely due to the unpopularity of NIRPs in Switzerland.

Finally, a comprehensive IMF study has shown that, at least by 2017, there was no evidence indicating that NIRPs have damaged banks overall profitability in the Eurozone; however there has been negative effects on net interest margins (Dell'Ariccia, et al., 2017). This effect was most likely offset by higher lending volumes, lower interest expenses, and increased fees by the banks. Turk (2016) notes however, that the effects of negative rates should be continuously monitored for several reasons, such as that the shift to fees might not be competitively sustainable by the banks. This conclusion is consistently supported by all research from different sources, all saying that NIRPs could potentially pose risks to financial stability if they are employed for a protracted period of time. A general concern is that the benefits of such an unconventional monetary policy might diminish over time thus they have to be combined with other fiscal and structural policies and help counter adverse shocks in the future (Arteta, et al., 2016).

As seen by the different theories and sometimes even contradictory results, research regarding the effects of NIRPs is still in early stages. The necessity of studying the topic by itself shows that there is a concern for banking stability in negative interest rate environments, which is also the reason why we chose to study this issue.

3. Methodology

In this chapter we will introduce the statistical framework that we are using to analyse our thesis question. This chapter includes two main parts, one with a short definition of the data we used, and a second which presents the methods we are using.

3.1. Data

The data we use in the regression models have two key elements, the policy interest rates and the Financial Soundness Indicators (FSIs). For the interest rates the major issue is that we are using policy interest rates, not any specific type of interest rates, such as deposit rates or lending rates, but the nature of policy rates varies across countries. As an example, the policy rate of the Sweden is set by the Sveriges Riksbank and they call it the REPO rate, which is currently -0.5%, while in Denmark it is set by the Denmark National Bank as the certificates of deposit rate, which is -0.65%. This poses some challenge in data collection, and it was necessary to manually gather the data in some cases as there is no comprehensive dataset including all of them.

The other side of the data are the Financial Soundness Indicators by the IMF which we take as the best collective indicators of banking stability. Out of the 12 Core FSIs, we did not analyse two indicators – sectoral distribution of loans, and net open position in foreign exchange to capital – because they provided no useful information regarding our topic. We also added the capital to assets indicator – which is not included in the Core Set by the IMF – to the capital adequacy indicators, because we believe that it can provide relevant results.

The FSI indicators are available quarterly for 112 countries, although with a lot of missing data, especially before 2010. Due to those missing data points, we take quarterly data for both the indicators and interest rates from Q1 2010 – Q4 2017.

In the descriptive statistics section, we also show the way we treated outliers, which results in two different datasets that we run regressions on, one with outliers included and the other where they are removed. Additionally, for around 40 countries quarterly GDP growth values were not available, therefore we had to use annual data converted to quarterly. Since this method had a small possibility of decreasing the significance of the regressions, we also split the dataset to one where we removed the countries that had no quarterly data available, and another where we used the annual data converted to quarterly. Even in the dataset where we removed countries, we have data for 82 countries which results in around 2600 data points for

each indicator. This amount of observations should generally be enough to be able to show statistically significant results.

Other than GDP growth, another control variable we are using is inflation (CPI) which is an important determinant of policy interest rates, according to the Taylor rule. This variable is also utilized as an instrumental variable (IV) in a two-stage least squares (2SLS) model.

In the following part, we describe how we use this data and what statistical tools we utilize to investigate our research question.

3.2. Statistical methods

We are investigating whether Negative Interest Rate Policies (NIRPs) have adverse side-effects on banking stability. As it was mentioned in the previous chapters, central banks implement NIRPs to reach various goals, such as inflation targets (Sweden) or currency pegging (Denmark). In principle, the indicators have no influence on policy interest rate changes, therefore a statistically significant relationship between them implies that interest rates are affecting banking stability and not vice versa. This one-way relationship is a crucial aspect for the analysis of our results, since establishing a causal relationship is fundamental to be able to answer our research question with a regression model.

The first part of the tests is a standard descriptive analysis for each indicator, where we present the general tendencies and basic features of the data. This may already provide some information regarding our thesis question and also helps in determining the quality and expectations for the outcomes for the regressions. The most important part of this segment is the comparison between the global average indicator values and the average values for banks in countries with NIRPs. The conclusions from this part are compared with the results of the models to check for consistency in the analysis section.

The descriptive statistics part is followed by the main test which is a panel regression in the following form for each indicator:

$$FSI_{it} = \alpha_0 + \beta_1 * I_{it} + \beta_2 * GDP_{it} + \beta_3 * INF_{it} + \beta_4 * D1 + \mu_i + \lambda_t + \varepsilon_{it}$$

FSI_{it} = Individual Financial Soundness Indicators

I_{it} = Policy interest rates

GDP_{it} = GDP growth

INF_{it} = Inflation (CPI)

D_1 = Dummy variable for negative interest rates

μ_i = Cross-section fixed effects

λ_t = Period fixed effects

ε_{it} = Error term

We are going to utilize OLS for this form of regression for each of the indicators for all four datasets. This model is further analysed by a Hausman tests for endogeneity, and for period and cross-section heterogeneity to find the correct model specification for each of the indicators. In theory, this model should give some results on what specific areas of stability do interest rates effect, which can provide much deeper conclusions than the original research question requires. In this form, GDP growth and inflation are simply used as control variables to take out their effects from the equation. The main outcomes from this model are β_1 and β_4. The former gives us indication of what effect do policy interest rates have on the indicators and the latter shows the effect at negative interest rates specifically. Additionally, we also look at μ_i – the country specific intercepts – to look at unmodelled differences between countries. These regressions are initially used with both cross-section and period fixed effects, as we can reasonably expect heterogeneity both between countries and periods. We also test this with a redundant fixed effects test and adjust the model if necessary.

Since there is also a concern for endogeneity in the equation above – due to the correlation between inflation and policy interest rates – we also run a two-stage least squares (2SLS) regression for each indicator, with inflation used as an instrumental variable (IV).

$$\text{First stage equation: } I_{it} = \alpha_0 + \beta_1 * GDP_{it} + \beta_2 * INF_{it} + \beta_3 * D_1 + \mu_i + \lambda_t + u_{it}$$

$$\text{Second stage equation: } FSI_{it} = \alpha_0 + \beta_1 * \hat{I}_{it} + \beta_2 * GDP_{it} + \beta_3 * D_1 + \mu_i + \lambda_t + v_{it}$$

FSI_{it} = Financial Soundness Indicators

$\hat{I}_{it}$ = Fitted policy interest rate value acquired from first stage equation

GDP_{it} = Control variable for GDP growth

INF_{it} = Inflation (CPI) used as an instrumental variable

D_1 = Dummy variable that takes the value of 1 when interest rate is < 0

μ_i = Cross-section fixed effects

λ_t = Period fixed-effects

u_{it}, v_{it} = Error terms

This model should control for concerns of endogeneity in the models. In a 2SLS model we first estimate the reduced form equations with the instrumental variable and save the fitted values ($\hat{I}$), which then we use in the second stage to estimate the structural equation, as shown above. If there is endogeneity originating from the relationship of inflation and policy interest rates, this model would give different results than the simple OLS model, in which case the results from this model should be the correct one. We also run a Hausman test for endogeneity that can signal endogeneity and also signal the strength of the model specification. Since there is a correlation between policy interest rates and inflation – which is the relevance condition of an IV – if a Hausman test shows no evidence for endogeneity in a model, it is because of the lack of relationship between the indicator and policy interest rates.

4. Statistical analysis

In this chapter we will first provide the results of the standard descriptive analysis for the whole dataset, and then we will provide the results of the regression models we used. With the descriptive statistics we will also provide some further information about the indicators we are using and their interpretations.

4.1. Descriptive statistics and outlier analysis

In this part, we will show the general characteristics of the whole dataset available for each indicator, both with and without outliers, if relevant. In the regressions however, we are only using data from 112 countries (see Appendix B), which is the number of countries that have data available for each of the indicators, GDP growth, inflation, and policy interest rates.

Outliers were defined as being three standard deviations from the mean. There is a concern that these outliers are mistakes in the data and some of those might influence our results, especially the R-square and the significance. Data from the Republic of Congo was entirely removed from the dataset, due to severe problems with consistency and probable mixed data with the Democratic Republic of Congo, which was already missing from the dataset. Since this outlier analysis might remove points that are relevant to our research, we are running the regression models both with and without outliers to mitigate this problem.

In the following part, we will show the descriptive statistics for each indicator. In the table 2, we included the mean, the standard deviation, the lowest average between 2010-2017 by country, and the highest average between 2010-2017 by country, for each indicator both for the data with and without outliers.

Table 2: Summary of Descriptive Statistics.

Variable	With outliers				Without outliers			
	Mean	**Std. dev**	**Min avg.**	**Max avg.**	**Mean**	**Std. dev**	**Min avg.**	**Max avg.**
Regulatory capital to risk-weighted assets	18.16	5.37	8.52	39.84	18.16	5.37	8.52	39.84
Regulatory Tier 1 capital to risk-weighted assets	15.91	5.46	7.65	34.44	15.91	5.46	7.65	34.44
Nonperforming loans not of provisions to capital	18.66	54.80	-11.09	229.34	17.83	35.78	-11.09	229.34
Nonperforming loans to gross loans	7.07	7.36	0.22	31.52	7.07	7.36	0.22	31.52
Sectoral distribution of total loans	88.61	15.67	24.51	100.00	88.61	15.67	24.51	100.00
Return on assets	1.66	1.78	-2.44	6.09	1.68	1.61	-1.76	6.09
Return on equity	14.65	16.89	-26.27	49.16	14.92	12.12	-10.14	49.16
Interest margin to gross income	59.34	15.91	9.11	92.77	59.33	14.09	9.11	87.68
Noninterest expenses to gross income	57.32	14.99	27.21	93.24	57.39	13.41	27.21	93.24
Liquid assets to total assets	28.20	13.18	8.65	70.02	28.20	13.18	8.65	70.02
Liquid assets to short-term liabilities	69.37	59.51	13.08	372.56	61.68	40.45	13.08	192.85
Net open positions in foreign exchange	10.00	40.00	-51.44	165.47	3.39	14.43	-51.44	43.33
Capital to assets	10.66	4.00	3.90	20.70	10.63	3.82	3.90	20.70

4.1.1. Regulatory capital to risk-weighted assets

The first indicator – regulatory capital to risk-weighted assets – is a capital-based FSI which is also often referred to as the Capital Adequacy Ratio (CAR), and it is calculated by adding up Tier 1 and Tier 2 capital and dividing by risk-weighted assets, as defined by the Basel Accords. Tier 1 capital is the core capital of a deposit taker, mainly consisting of common stock and disclosed reserves. Tier 2 capital is the supplementary capital which includes undisclosed reserves, revaluation reserves, general provisions, hybrid debt capital instruments, and subordinated term debt (Basel Committee on Banking Supervision, 2017). Risk weighting is done by using the assigned credit risk percentage weights for all assets provided by national regulators. As set out by the Basel III, banks must maintain at least 8% CAR and Tier 2 capital is limited to 100% of Tier 1 capital (Basel Committee on Banking Supervision, 2017, p. 12). A higher ratio of capital to assets is a sign of higher financial stability in a bank. The IMF has quarterly data for 127 countries for this indicator in the period 2010-2017. Our dataset shows that the overall average ratio for all countries is 18.16 with a standard deviation of 5.4. The highest average ratio during the period was in the Maldives with 39.84 and the

lowest was Cameroon with 8.52, which is barely over the regulatory minimum. An important characteristic of the data is that it is consistently growing over the studied period in terms of global average. Figure 1 shows, that the overall average for countries which have at some point implemented NIRPs (Eurozone, Japan, Sweden, Denmark, and Switzerland) is lower than the global average with only 17.2, but the value is growing faster than the global average and outgrows it by 2015. There were no outliers present in this dataset. Due to the consistency of this dataset there is a good hope of finding statistically significant results.

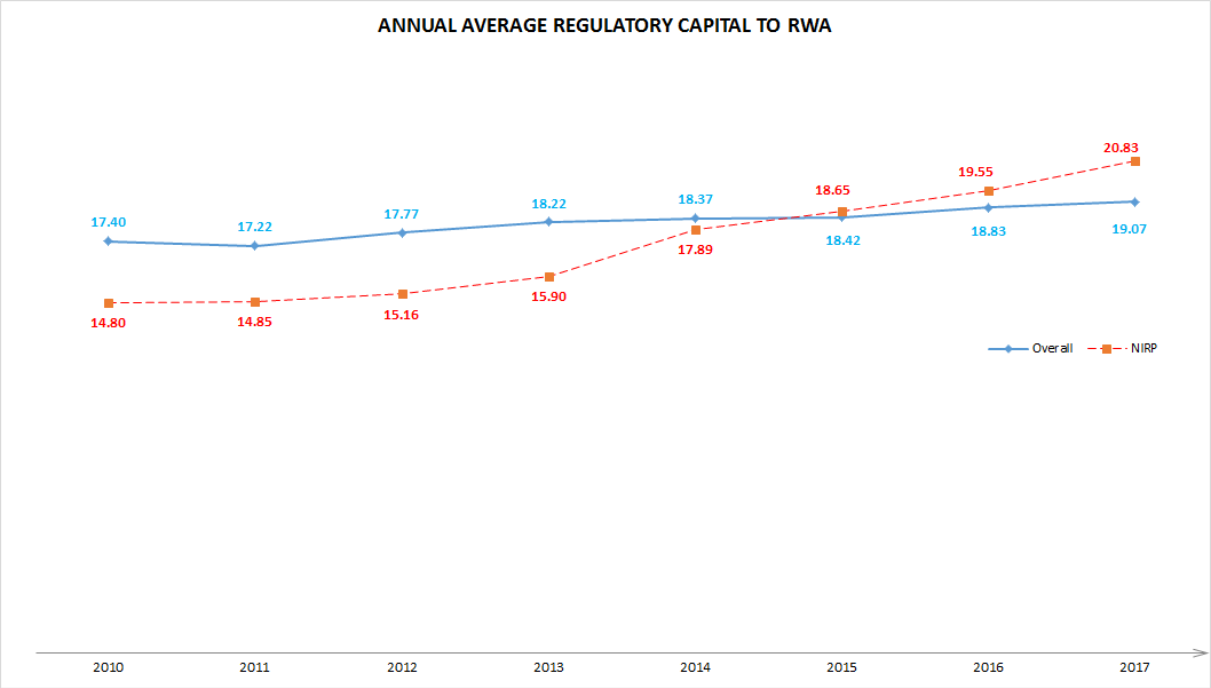

Figure 1: Regulatory capital to RWA

4.1.2. Regulatory Tier 1 capital to risk weighted-assets

Regulatory Tier 1 capital to risk-weighted assets is the narrower measure of the previous indicator, and Tier 1 capital is defined as described above. Basel III sets the minimum requirement for Tier 1 capital at 6% of total capital for banks. Naturally, a higher value is better for banks' stability. In our dataset we had data for this indicator from 125 countries, where the average is 15.91 and standard deviation is 5.46. The highest average of any country is 34.44 from Tonga, and the lowest is 7.65 from Cameroon. Similarly, to the previous indicator, the global average Tier 1 capital ratio is consistently growing over time. For negative interest rate countries, the average is 15.24, which again is lower than the global average, but their average is consistently growing and is higher by 2015, as seen in figure 2. There was only one outlier point from Zambia 2017 Q4, which was removed.

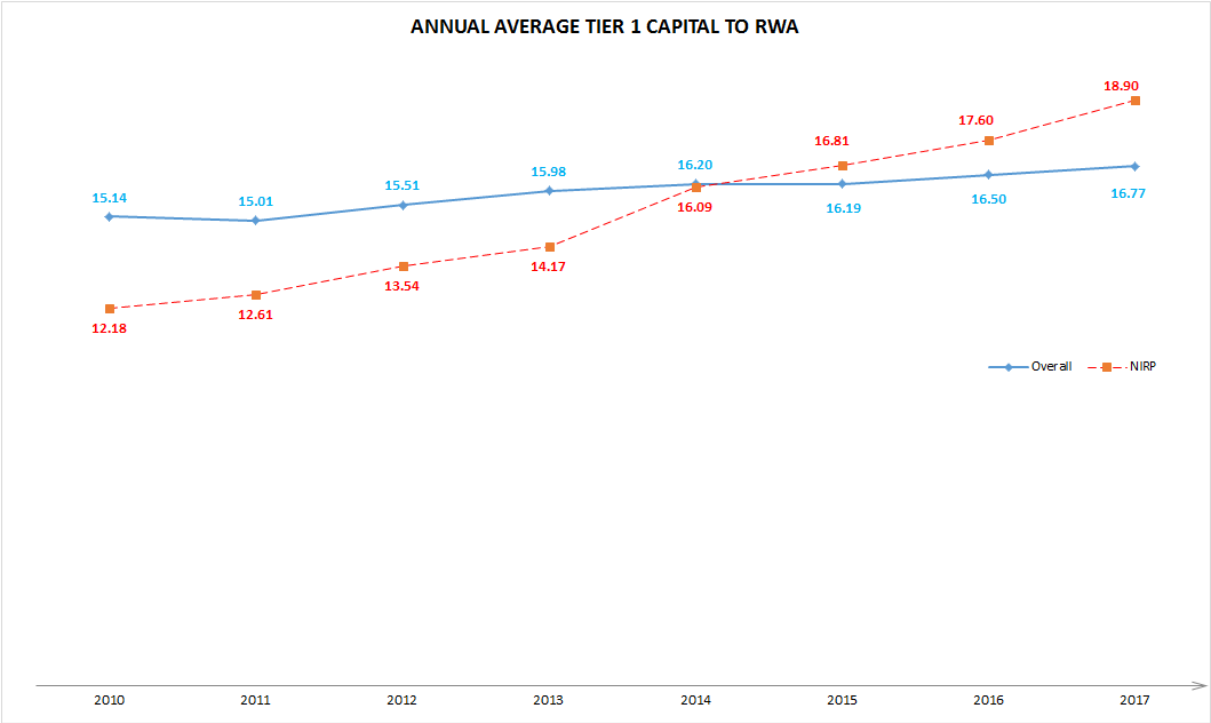

Figure 2: Annual average Tier 1 capital to RWA.

4.1.3. Nonperforming loans net of provisions to capital

The third indicator and the last measuring capital adequacy is nonperforming loans net of provisions to capital. This indicator shows the potential impact of nonperforming loans on the banks' capital; therefore, generally lower value would be preferred by a bank, since a higher ratio indicates that a bank has lower capacity to withstand NPL-related losses (International Monetary Fund, 2006). This indicator is calculated by dividing the value of NPLs less the value of specific loan provisions, by total regulatory capital.

In our dataset we had data from 125 countries. In this case there was only one outlier we decided to remove: in Nigeria 2010 Q3 with a value of 2434. With this one outlier included the worldwide average is 18.66, without it is 17.83. The standard deviation is very high, 54.8 with this outlier included and 35.78 without, showing that there are probably big differences between countries. The highest average value from all countries is 229.34 from San Marino, while the lowest is -11.09 from Brazil. It is also notable that San Marino, Cyprus, and Greece both have very high values that would qualify them as outliers, but the numbers are consistent both between quarters and with world news about NPL-related issues in these countries. Even without these countries however, we can see on figure 3, that the NIRP countries on average have substantially higher NPL to capital ratio than the global average, possibly signalling some NPL-related problems. We hope that the fixed effects models can capture the country

specific effects and produce results with high explanatory power, but even if we get good results this indicator is most likely used rather for asset quality than for capital adequacy.

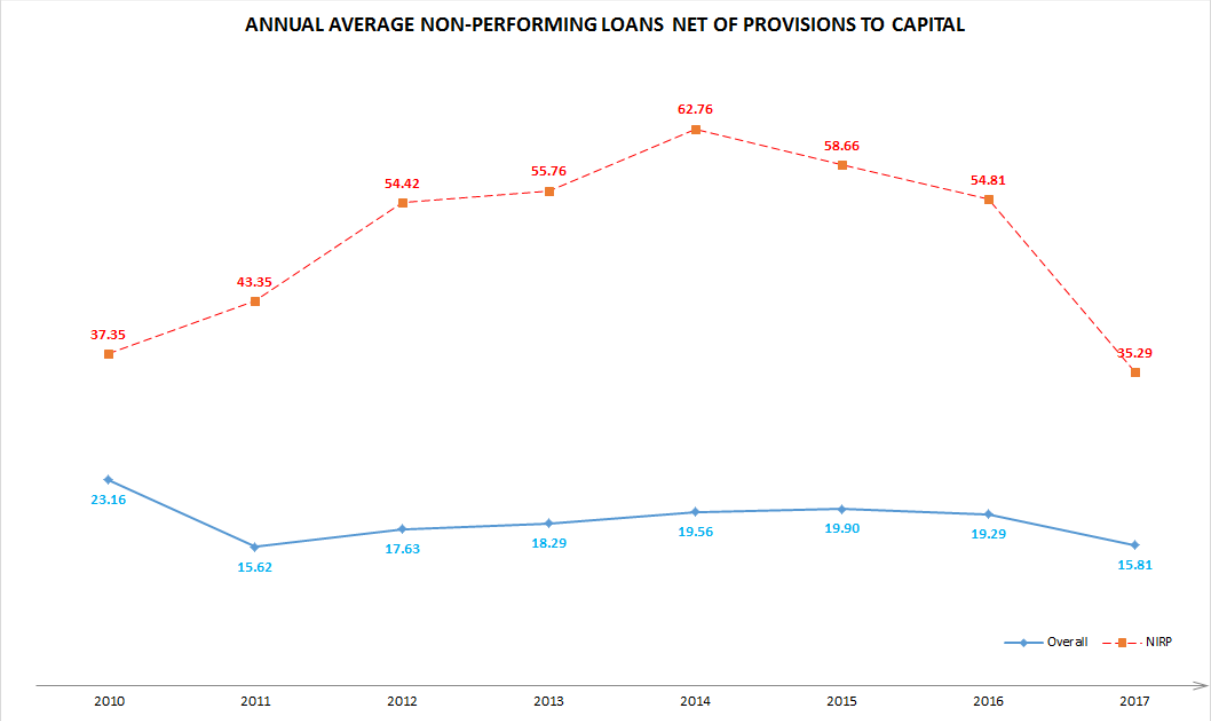

Figure 3: Annual average Non-Performing Loans net of Provisions to Capital.

4.1.4. Nonperforming loans to gross loans

The first indicator for asset quality is nonperforming loans to gross loans, which is an asset-based indicator used to identify problems with asset quality in the loan portfolio, and often used in combination with the previous indicator (nonperforming loans to capital). An important quality of this indicator is that it is generally backward-looking, given that NPLs are usually recognized after problems emerge. For this reason, the capability of an NPL-based indicator to signal issues with loan portfolio and possibly even forecast issues could be limited. The indicator is calculated by dividing the value of NPLs by the total value of the loan portfolio, and naturally lower values are better for the banks.

We had data for this indicator from 125 countries. The global average value was 7.07 with a standard deviation of 7.36. The highest average value again belonged to San Marino with 31.52 and again Greece and Cyprus had outlier-level values that were left in the data since we know that the data is realistic. The lowest average was Macau with 0.22. As shown on figure 4, negative interest rate countries again show that they have much higher rate of NPLs, although if we do not count San Marino, Greece, and Cyprus they actually have lower ratio since 2016. No outliers were removed from this dataset, although it shows the same 'top-heavy' characteristics as the previous indicator, but the data is generally consistent with real

life events. Based on the similarities, we expect consistent results between this indicator and NPL to capital.

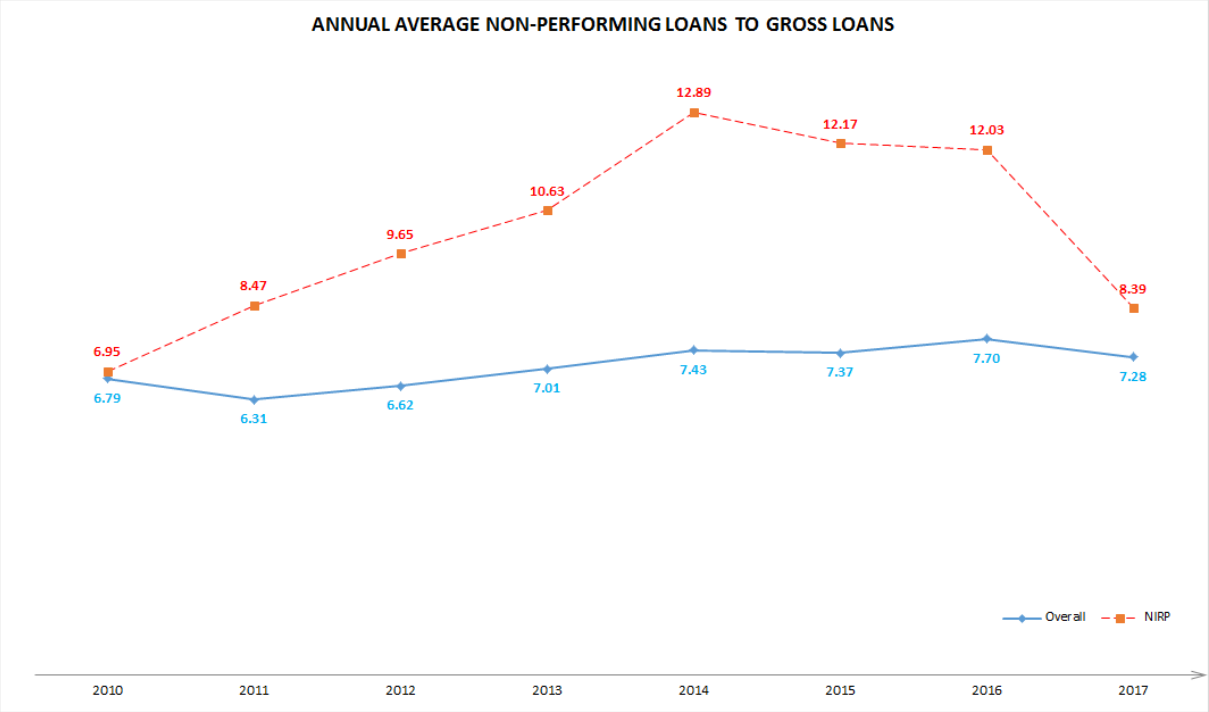

Figure 4: Annual average Non-Performing Loans to gross loans.

4.1.5. Return on assets

The first indicator measuring earnings and profitability is return on assets which is a standard measure of the efficiency in using available assets to generate returns. It is calculated by dividing net income by the average value of total assets over the same period. Naturally, higher values indicate higher financial stability.

In our dataset we had data from 126 countries. For this indicator three potential outlier points were identified, two from 2010 in Afghanistan with a value of -25.61 and -19.88 that were removed and one from Ukraine 2015 a value of -23.53 that was also removed. The overall average with these outliers included is 1.66 with a standard deviation of 1.78, and 1.68 with a standard deviation 1.61 without. In both cases however, the lowest average return on assets belongs to Ukraine (-2.44 and -1.76) and the highest is Malawi with 6.09. Figure 5 shows that countries with negative interest rates have substantially lower average return on assets in all periods than the global average, although the ratio is growing and almost tripled from 2010 to 2017, from 0.24 to 0.73. The overall average for NIRP countries is 0.44. This by itself is an interesting fact, but we hope that the regression models will give some more significant results.

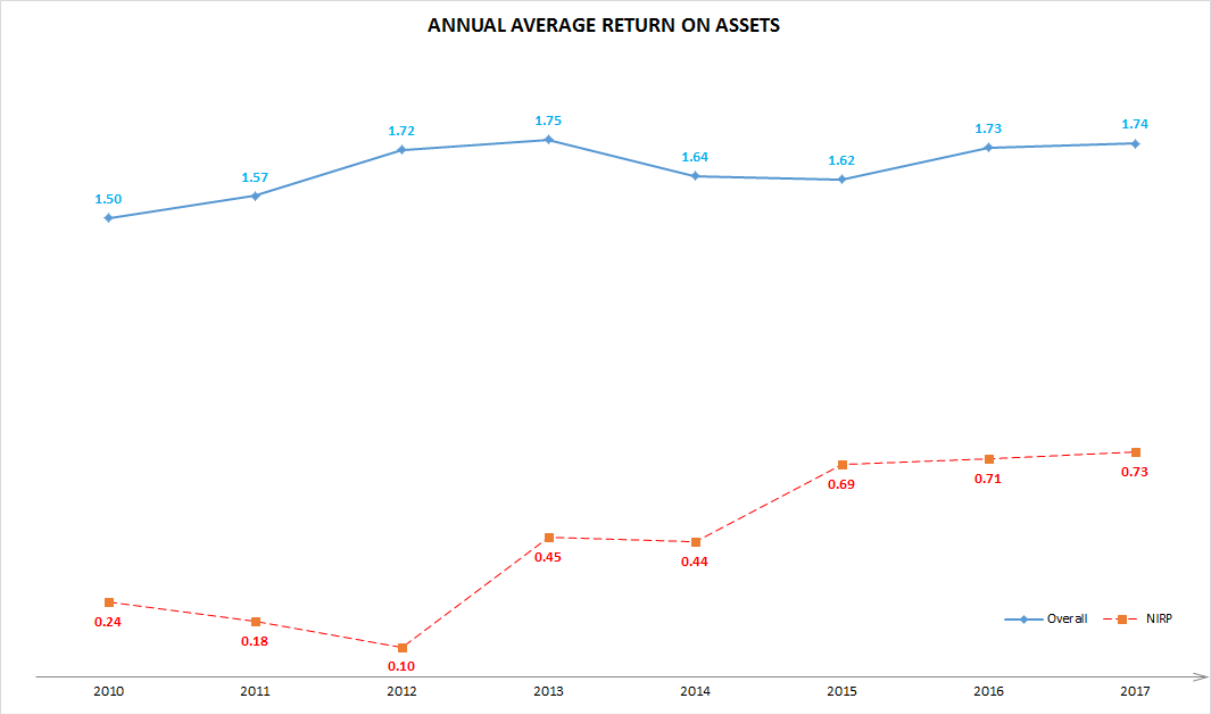

Figure 5: Annual average return on assets.

4.1.6. Return on equity

The next indicator measuring earnings and profitability is return on equity which is often used in pair with return on assets. It measures the banks' efficiency in using their capital, and it is calculated by dividing net income by the average value of capital over the same period. In itself this indicator gives unclear conclusions, since a high ratio could indicate both high profitability and low capitalization, therefore not giving clear information about profitability. For this reason, this indicator is interpreted in combination with capital adequacy ratios to get a sense of capitalization levels first.

In our dataset we have data for 126 countries with seven outliers removed from Afghanistan 2010 Q4 (-505.64), Ukraine 2015 and 2016 (-277.33, -147.25, and -122.17), Kazakhstan 2010 Q1 (165.28), Gabon 2017 Q2 (134.64), and Slovenia 2013 Q4 (-97.62). All of these values are far out of the three standard deviation limit; therefore we decided to remove them. With these outliers included the global average return on equity is 14.64 with standard deviation 16.89, and without these it is 14.92 with standard deviation 12.12.

The lowest average country is Ukraine in both cases (-26.27 with outliers and -10.14 without), while the highest is Papua New Guinea with 49.16. Similarly to the previous indicator, negative interest rate countries have much lower return on equity than the global average, around third (5.45), as seen on figure 6. This possibly indicates that the issue is not with asset value or capital, but banking returns.

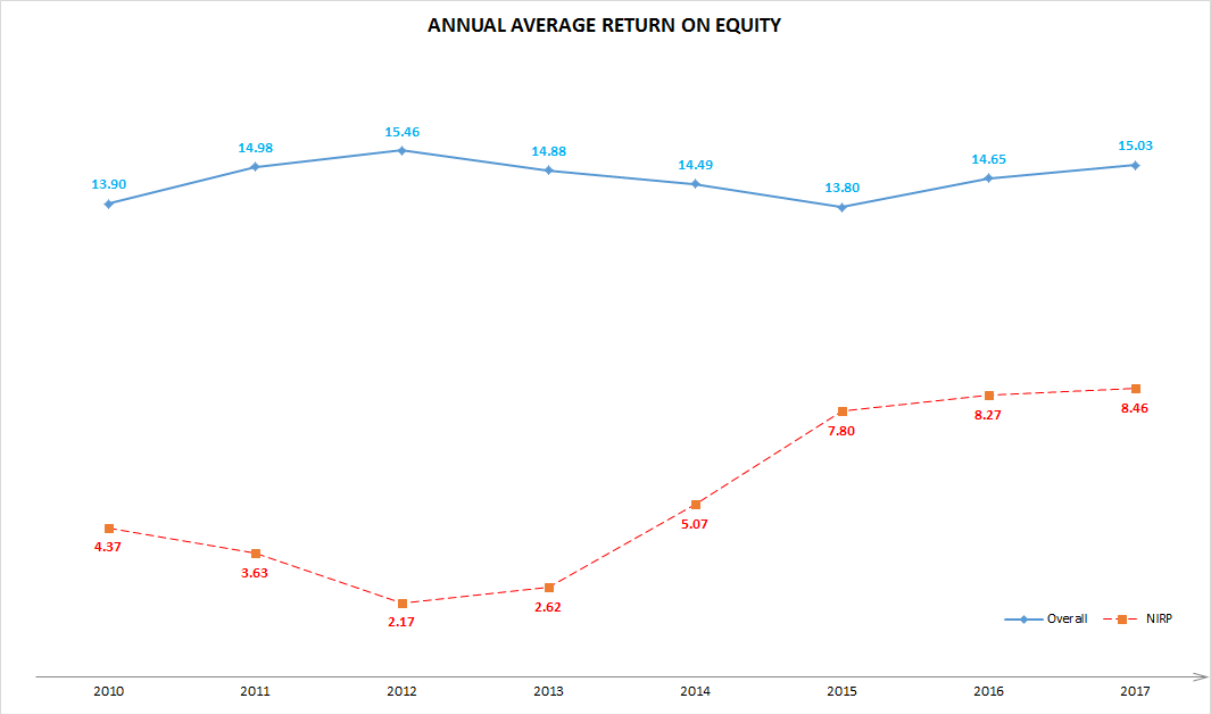

Figure 6: Annual average return on equity.

4.1.7. Interest margin to gross income

The next indicator, interest margin to gross income measures the relative share of net interest earnings within gross income. It is calculated by dividing net interest income – which is interest earned less interest expenses – with gross income. This indicator should generally be interpreted in combination with capital to assets ratio, since higher capital leads to lower interest expenses, thus a lower interest margin to gross income ratio (International Monetary Fund, 2006). A higher indicator value means that a higher ratio of a bank´s income is interest-based. Since interest margins are key parts of banks´ income, it is possible to argue that a higher ratio of interest margin to gross income is a sign of higher financial stability. In country level aggregate data however, the difference between a higher and a lower indicator value indicates little about stability, since we know nothing about portfolio diversification, and the riskiness of non-interest income generating activities. These could be simple fees, which are considered safe, or income from trading activity.

In our dataset we had data from 126 countries, with four outliers from Ireland 2010 (149.12 and -294.33) and Bhutan 2012 (255.61 and 142.77), which were removed. The average with outliers is 59.34 with standard deviation 15.91, and 59.33 with standard deviation of 14.09 after removing them. The lowest overall average is from Paraguay with 9.11, while the highest is Bhutan with 92.77 with outliers and Albania with 87.68 after removing outliers. Generally, interest margins for negative interest rate countries are at the same level as the

global average, 58.96 with a slight downtrend over the years, but no visible trend that could be used in an analysis, as seen on figure 7.

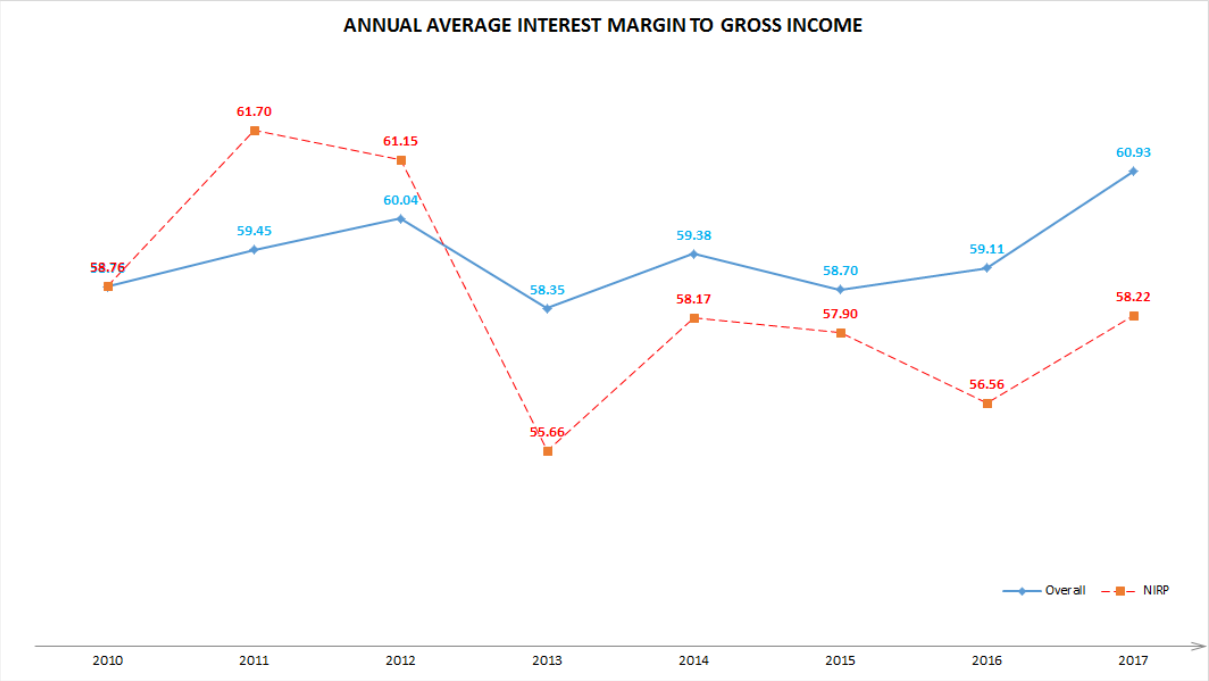

Figure 7: Annual average Interest margin to gross income.

4.1.8. Non-interest expenses to gross income

The last indicator measuring earnings and profitability is noninterest expenses to gross income, which is a measure of administrative or operating expenses compared to gross income. It is calculated by dividing noninterest expenses by gross income. Generally, a lower level of noninterest expenses is preferred given the same gross income, but it highly depends on the type of bank and other qualities, such as size and the type of bank (investment bank, commercial bank, etc.). For this reason, the interpretation of this indicator is limited, as the level of the indicator gives unclear information, even if coupled with other indicators. On a country level, for which data from all the banks are aggregated, the single data points are difficult to assign relevant meaning to.

We had data from 126 countries with three outliers from Nigeria 2011 Q3 (171.29) and Ireland 2010 (186.61 and -303.46) that were removed. The global average is 57.32 with a standard deviation of 15 with outliers and 57.39 with a standard deviation of 13.41 without outliers. The highest average country is Belarus with 93.24 and the lowest is the Maldives with 27.21. The average for negative interest rate countries is 62.92 and consistently higher than the global average, as seen on figure 8.This might be caused by lower gross income or higher noninterest expenses however, so few conclusions can be drawn from this data.

Generally, we do not expect to get a lot of information from the results of the regression models for this indicator, even if they are significant.

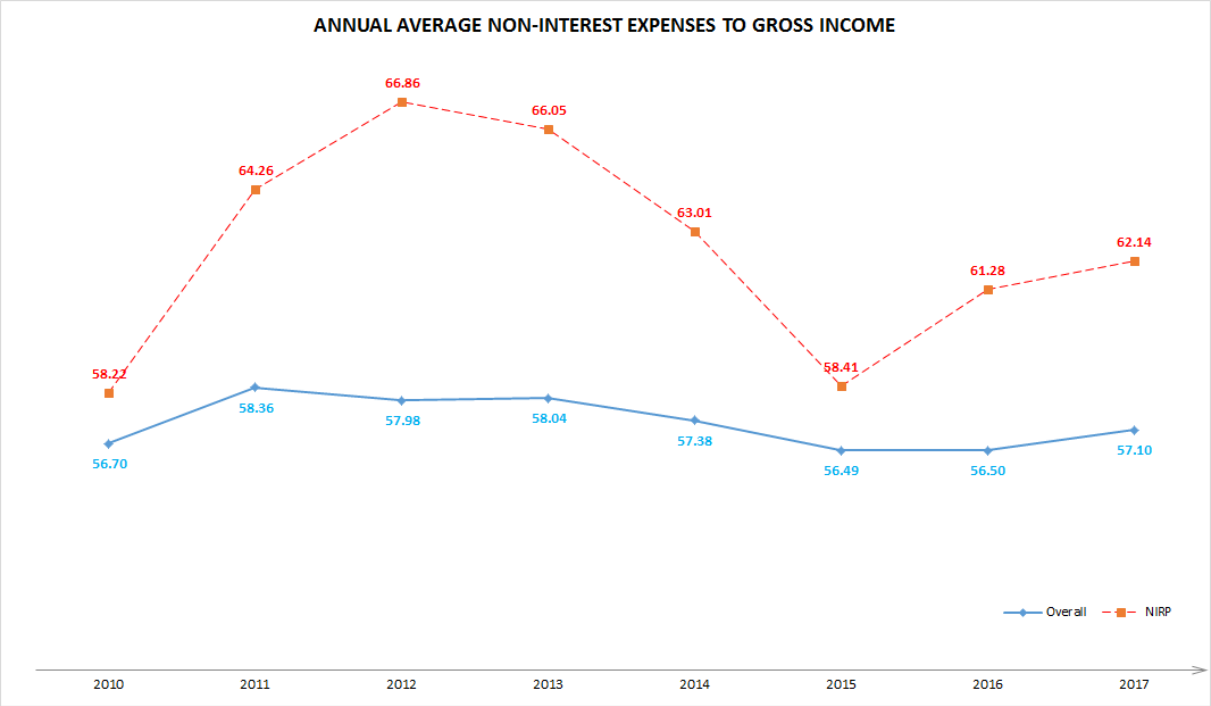

Figure 8: Annual average Non-interest expenses to gross income.

4.1.9. Liquid assets to total assets

Liquidity is measured by liquid assets to total assets ratio or liquidity ratio in another name, which is an assets-based indicator measuring the ability of banks to meet demand for cash. It is calculated by dividing liquid assets by total assets, and a higher value is generally indicates higher financial soundness. In the Basel III regulations the measure for liquidity is liquidity coverage ratio (LCR), therefore there is no regulation limit for this indicator specifically, although it is a common measure of liquidity. Liquidity is the one indicator group that is difficult to theoretically tie to negative interest rates, therefore we do not necessarily expect significant results from the regressions. A possible explanation for a relationship would be that in a low interest rate environment banks might restructure their portfolio to more illiquid asset, such as structured products (CDOs, CLOs, ABS, etc.) or derivatives (options, forwards, futures, etc.).

We have data for 126 countries with no outliers. The global average during the period was 28.2 with a standard deviation of 13.18 and quite stable over time with no trend in any direction. The highest average value belonged to Singapore with 70.02 and the lowest to Swaziland with 8.65. The average for negative interest countries is a bit lower than the global average with 25.82 with also no discernible trends in any ways, as seen in figure 9. From this

data we infer that liquidity is a generally a very stable characteristic of a banking sector in a given country, therefore we probably will not see significant coefficients for policy interest rates. This stability is not surprising given that liquidity is highly controlled by regulatory agencies.

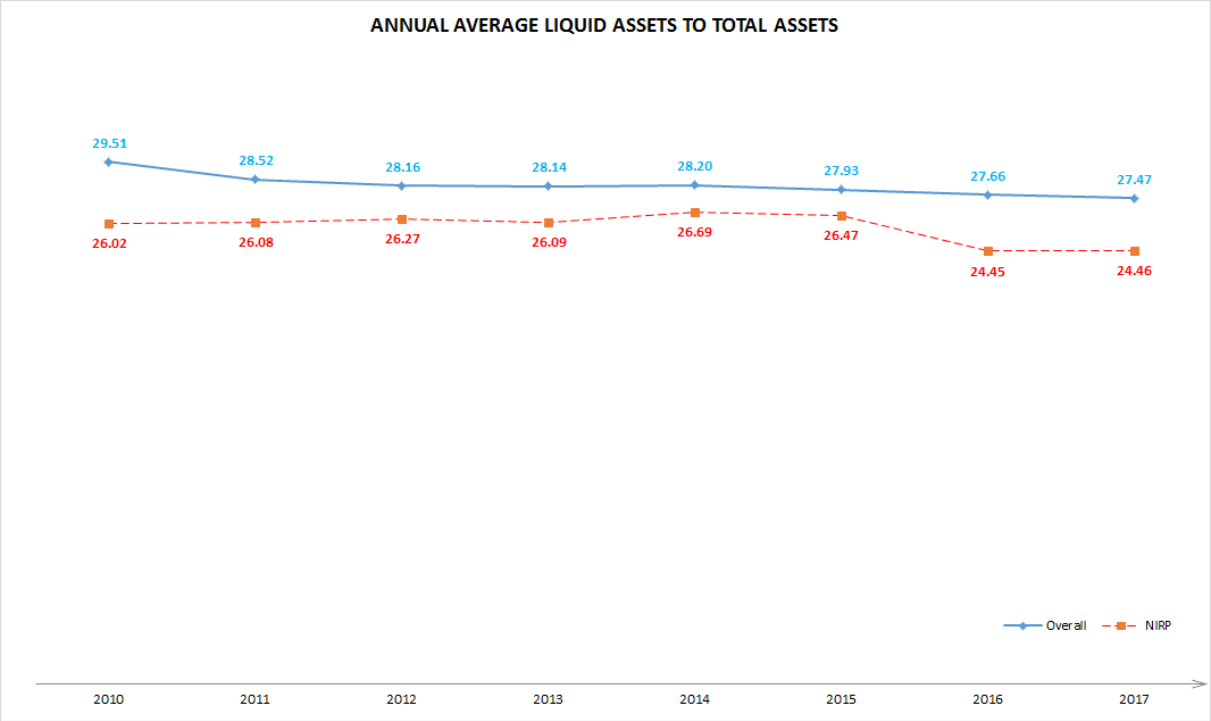

Figure 9: Annual average Liquid assets to total assets.

4.1.10. Liquid assets to short-term liabilities

The other indicator measuring liquidity is liquid assets to short-term liabilities, which is intended to capture liquidity mismatch of assets and liabilities. A low ratio could indicate that the bank is unable to meet short-term withdrawal of funds without liquidity problems. It is calculated by dividing liquid assets with short-term liabilities and a higher ratio is generally better. Same as the previous indicator, we do not expect to see a strong relationship with policy interest rates.

We had data for 123 countries, but some countries such as Equatorial Guinea (196.32), Central African Republic (179.25), the Dominican Republic (372.56), and Rwanda (213.13) had extremely high average values compared to their liquid assets to total assets ratio, which is difficult to explain and also were out of the three standard deviations limit therefore they were removed. This lowers the global average from 69.37 to 61.68, but the standard deviation also decreases to 40.45 from 59.51. Figure 10 shows that there is a weak decline in global average, especially from 2016 to 2017. The highest average before removing outliers is the Dominican Republic with 372.56 and Brazil with 192.85 after. The lowest average is

Swaziland with 13.08. Overall the data is somewhat inconsistent with liquid assets ratio, even after removing outliers. The average for negative interest rate countries is 62.73 which is basically the same as the global average and shows the same weak decline.

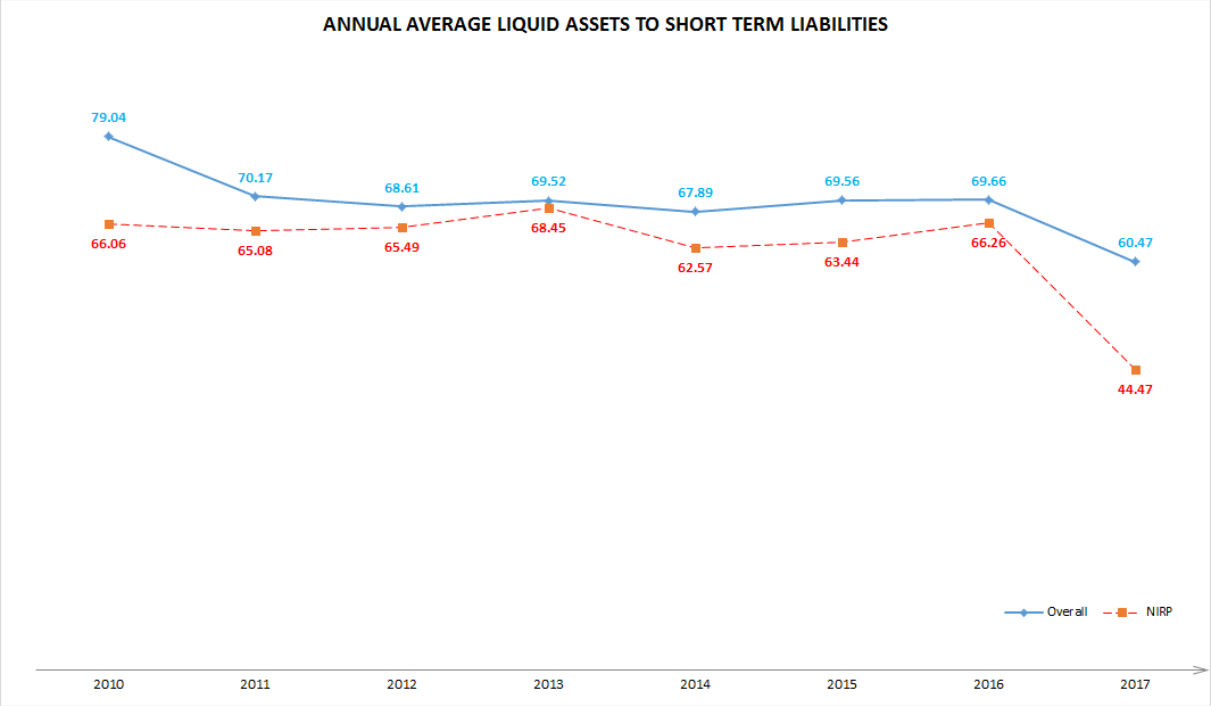

Figure 10: Annual average Liquid assets to short term liabilities.

4.1.11. Capital to assets

One ratio from the Encouraged Set that we are studying is capital to assets, or financial leverage in another name. It measures the extent to which assets are funded by other than own funds, which is basically another measure for capital adequacy, thus higher value indicates financial stability. It is calculated by dividing capital and reserves with total assets. Due to its similarities to capital adequacy ratios, we will analyse this indicator together with the other three capital adequacy indicators.

We had data from 124 countries, with only two outliers from Israel 2011 (60.05 and 54.96) that were removed. The overall average is 10.66 with outliers and 10.63 without, and the standard deviation is 4 and 3.82 respectively. The highest average is from Central African Republic in both cases with 20.7, while the lowest is 3.9 from China Macao. The average in negative interest rate countries is 7.78 which is consistently lower than the global average over the years, but it shows an upward trend as seen in figure 11, similarly to the core indicators for capital adequacy.

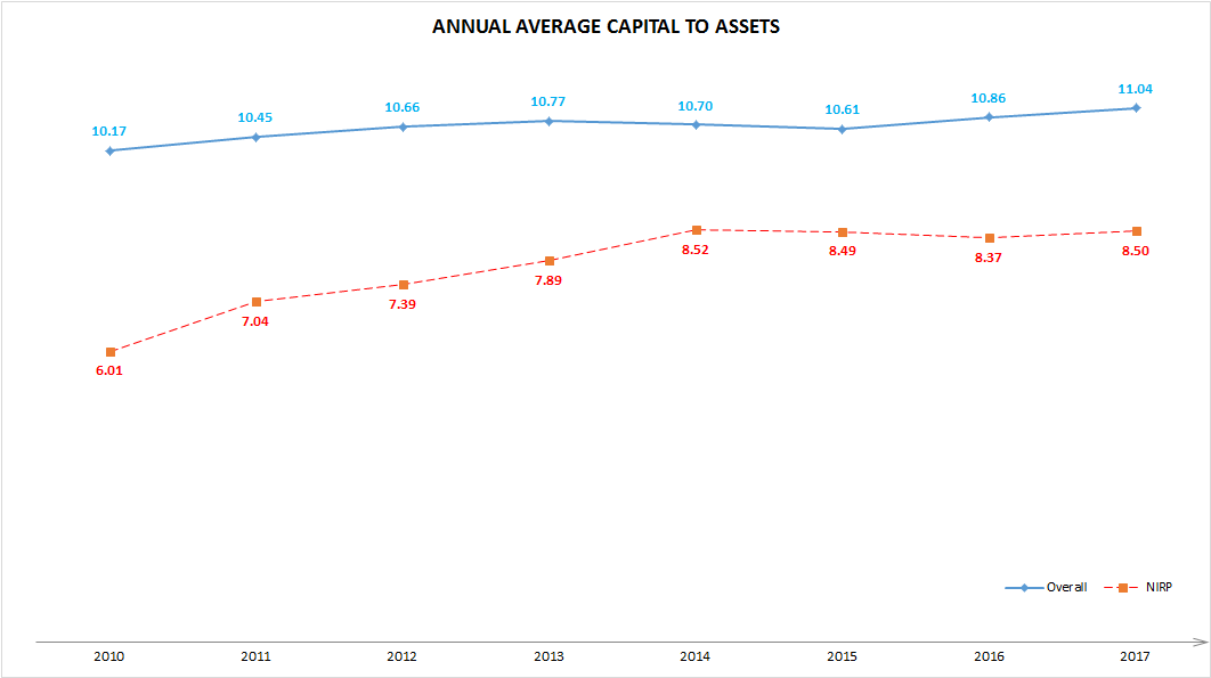

Figure 11: Annual average capital to assets.

4.1.12. Policy interest rates

Finally, we also collected data for policy interest rates from 112 countries. These had an average of 4.96% and a standard deviation of 5.31%. The highest average interest rate during 2010-2017 was in Belarus with 21.48%, and the lowest was in Denmark with -0.12% which was the first country to implement negative interest rates in 2012. Overall during these eight years we studied, no strong trend is visible in any direction in interest rates (see figure 12).

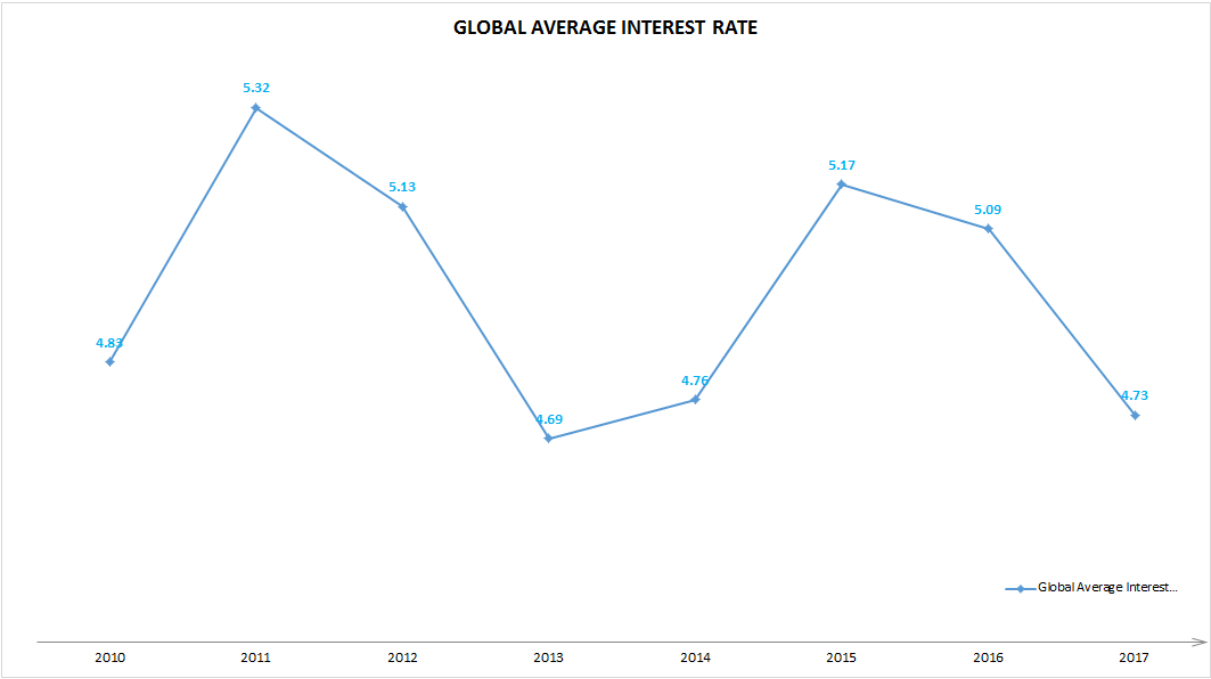

Figure 12: Global average interest rate.

4.2. Regression results

In this part we will present the results for our regressions for all the indicators with an explanation for the reasons why we are using the given model and the diagnostics tests we ran. More detailed look into the results and interpretation will be included in the following chapter.

4.2.1. Regulatory capital to risk-weighted assets

For the first indicator, a simple Hausman test reveals that the concern for endogeneity in policy interest rates is legitimate (see Appendix A), and this is confirmed by the difference between the results for the simple OLS model and the 2SLS model. Because of this, we must use the results from the 2SLS regressions, since the OLS model is biased in the presence of endogeneity.

Since there were no outliers removed, there is no difference between those two datasets, however, there is an inconsistency between the datasets as countries that had no quarterly data available were removed. Since that problem is mostly relevant for GDP, which is not a key indicator in this model, we work with results from the main dataset. The redundant fixed effects test also confirms that the cross-section and period fixed effects specification is correct. The results presented in table 3 show that the coefficient for policy interest rates is 0.2628 and for the negative interest rate dummy it is 3.3249, both with high significance and the R-squared value of 0.7715 also shows a relatively strong explanatory power.

Table 3: Regulatory capital to risk-weighted assets 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	16.1001	34.2651	0.0000
Policy interest rate	0.2628	2.71832	0.0066
Real GDP growth rate	0.016	1.00666	0.3142
Negative interest dummy	3.3249	14.7275	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.7715	0.7599	72.3418	0.0000

4.2.2. Regulatory Tier 1 capital to risk-weighted assets

The second indicator for capital adequacy shows very similar results than the first, both in terms of endogeneity concerns and numerically. The effect of outliers is negligible, and the same difference between datasets persists as described above. Table 4 shows that the final

values for the coefficients are 0.2469 for interest rates and 3.2675 for the dummy, both with high significance and an overall R-squared of 0.7879. Both the cross-section and period fixed effects are correct assumptions according to the redundant fixed effects tests.

Table 4: Regulatory Tier 1 capital to risk-weighted assets 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	13.7551	29.2316	0.0000
Policy interest rate	0.24692	2.54512	0.0110
Real GDP growth rate	0.01959	1.22965	0.2189
Negative interest dummy	3.26746	14.4351	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.7879	0.7769	77.9049	0.0000

4.2.3. Nonperforming loans net of provisions to capital

For the third indicator for capital adequacy the redundant fixed effects test shows some evidence that period fixed effects might be redundant, but not strong enough to warrant using only cross-section fixed effects. Additionally, removing period fixed effects produces essentially the same results, only less significant. Not removing outliers also significantly lowers the explanatory power of the regressions, therefore those datasets were ignored for this indicator. The dataset for which annual data is removed also produces insignificant results, thus is ignored. Overall however no model provided results that would prove the coefficient for interest rates significantly different from zero, as seen in table 5. The coefficient for the negative interest rate dummy is however, significant with a value of 7.3782. The final R-squared is 0.7388.

Table 5: Nonperforming loans net of provisions to capital 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	14.9725	3.8430	0.0001
Policy interest rate	0.7118	0.9101	0.3628
Real GDP growth rate	-0.0502	-0.3913	0.6956
Negative interest dummy	7.3782	3.9239	0.0001
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.7388	0.7254	55.3925	0.0000

4.2.4. Nonperforming loans to gross loans

The Hausman test for nonperforming loans to gross loans shows that the policy interest rate is not strictly endogenous in this case, therefore we can use the results from the simple OLS models although 2SLS is still preferred. Since the Hausman test we have done for the first indicator is valid for any indicator, this test signals that the endogeneity problem is mitigated by the lack of a relationship between the indicator and policy interest rates. This is demonstrated by the weak significance of the regressions.

The dataset in which countries with only annual data were removed produced similar results to the original dataset, only with weaker significance and since no outliers were removed from this indicator, the most consistent results are given by the full 112 country dataset. As in the indicator before, no regression proved that the coefficient for interest rates would be significantly different for zero as shown in table 6, but the negative interest rate dummy had a significant value of 2.4893. The final R-squared value is 0.7475.

Table 6: Nonperforming loans to gross loans 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	5.9203	7.7961	0.0000
Policy interest rate	0.1878	1.2369	0.2162
Real GDP growth rate	0.013	0.5235	0.6007
Negative interest dummy	2.4893	6.7742	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.7475	0.7346	58.898	0.0000

4.2.5. Return on assets

The Hausman test for endogeneity here also showed that endogeneity in policy interest rates is a concern, therefore only results from the 2SLS model are used. Given that only 2 data points were removed as outliers it is not surprising that the difference between the results with and without outliers is small, although the R-squared is higher without outliers, as expected. The dataset without the countries that only had annual data also gives the same results, with a lower R-squared value. The redundant fixed effects test also confirmed that cross-section and period fixed effects specification is correct. Table 7 shows that the final coefficients are all significant, and it is -0.1842 for interest rates and 0.3736 for the negative interest rate dummy. The final R-squared is 0.6153.

Table 7: Return on assets 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	2.3931	11.677	0.0000
Policy interest rate	-0.1842	-4.4374	0.0000
Real GDP growth rate	0.0174	2.7124	0.0067
Negative interest dummy	0.3736	4.0024	0.0001
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.6153	0.5949	38.8872	0.0000

4.2.6. Return on equity

In the case of return on equity, the Hausman test shows that the policy interest rate is not endogenous, but –as in nonperforming loans to gross loans – this should only happen because interest rate is not a statistically significant predictor of the indicator. Outliers in this data were very influential on the results despite only 7 observations being removed, they turned into a significant negative coefficient for policy interest rates but with a much lower R-squared than the other regressions. Since this is obviously caused by a low number of big outliers, the results from these regressions are not used as we are not interested in the effects of extreme data points, which are possibly incorrect. The difference between removing the countries without quarterly data or constructing them is minimal, but the full dataset is more significant. The two-way fixed effects specification proved to be the best one by the redundant fixed effects test. Overall, it is confirmed by the regressions that the policy interest rate is not a good predictor of return on equity, as its coefficient is not significant for the policy interest rate variable (see table 8). The coefficient for the dummy is, however, significant with a value of 4.586. The final R-squared is 0.6798.

Table 8: Return on equity 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	15.502	8.2778	0.0000
Policy interest rate	-0.3221	-0.8464	0.3974
Real GDP growth rate	0.0818	1.7686	0.0771
Negative interest dummy	4.5860	6.6600	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.6798	0.6626	40.3497	0.0000

4.2.7. Interest margin to gross income

For interest margin to gross income, the result of the Hausman test for endogeneity shows that policy interest rate is not endogenous which is due to the lack of a relationship between the interest rates and the interest margin to gross income since the relationship between interest rates and inflation is already well established as described earlier. There were only 2 observations removed as outliers and those are extreme and very likely mistakes in the data, therefore results with outliers included are not used further. The results from the smaller dataset – for which countries without quarterly data were removed – are similar to the results from the full dataset with higher R-squared and more significance. Given the results from the OLS and 2SLS models from the two datasets, the real value for the coefficient of policy interest rates is negative and close to zero with low significance, and the coefficient for the negative interest rate dummy is between -2 and -3. The R-squared is 0.8479, as seen in table 9. Overall the explanatory power of the regression is low.

Table 9: Interest margin to gross income 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	60.5398	56.3510	0.0000
Policy interest rate	-0.2680	-1.2539	0.2100
Real GDP growth rate	-0.0278	-0.7489	0.4539
Negative interest dummy	-3.0800	-5.6367	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.8478	0.8397	105.1047	0.0000

4.2.8. Non-interest expenses to gross income

Due to the results of the Hausman test - which shows endogeneity - we are only using the results from the 2SLS models. The redundant fixed effects tests confirmed that the two-way fixed effects specification is correct. The three outliers that were removed are also proved to be correctly removed since the regression with them included is both less significant and has a lower R-squared. The difference between removing countries with no quarterly GDP data or converting annual to quarterly in this case gave no significantly different results. Table 10 show the final coefficient for interest rates, which is -0.8 and significantly different from zero, and -3.112 for the negative interest rate dummy which is also significant. The final R-squared is 0.7657.

Table 10: Non-interest expenses to gross income 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	61.4135	48.8333	0.0000
Policy interest rate	-0.8004	-3.1967	0.0014
Real GDP growth rate	0.0434	0.9994	0.3176
Negative interest dummy	-3.1123	-4.8678	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.7656	0.7531	62.3466	0.0000

4.2.9. Liquid assets to total assets

The Hausman test again shows that the relationship between interest rates and the indicator is not strong, indicating that the results of the regressions will not be significant. The redundant fixed effects test presents evidence that period fixed effects are redundant and thus only cross-section fixed effects were used. Since there were no outliers removed from this data, there is no difference between datasets with and without outliers. The difference between the two datasets with and without countries with only annual data is marginal but removing them gave the same results with higher significance and R-squared. The simple OLS models also gave virtually the same results as the 2SLS regressions. Overall, the coefficient for interest rates is insignificant although the simple OLS models suggest that they might be very low (0.1) but significant. The coefficient for the negative interest rate dummy is consistently significant and it is around 0.8, as shown in table 11. The R-squared in all the regressions is over 0.91.

Table 11: Liquid assets to total assets 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	26.0884	40.5262	0.0000
Policy interest rate	0.1988	1.3061	0.1916
Real GDP growth rate	0.0303	1.1344	0.2567
Negative interest dummy	0.7805	2.2326	0.0257
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.9136	0.9101	260.4694	0.0000

4.2.10. Liquid assets to short-term liabilities

The Hausman test shows that that the relationship between interest rates and the indicator is not strong, since it shows no evidence of endogeneity. As discussed before, we know that there is a relationship between policy interest rates and inflation, therefore an insignificant Hausman test signals that the relationship between policy interest rates and the indicator is not significant. The redundant fixed effects test confirms that the two-way fixed effects specification is correct. Although there were a relatively large amounts of outliers removed (data for 4 countries), since entire countries' data was removed, the difference in results between regressions with and without outliers is small. Overall, all four datasets provided almost identical results and the 2SLS and OLS models also had the very similar results. From these we can be confident that the policy interest rate is not a statistically significant predictor of liquid assets to short-term liabilities as shown in table 12, but the coefficient for the negative interest rates dummy is around -11. The R-squared is 0.8866.

Table 12: Liquid assets to short-term liabilities 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant	63.5934	25.317	0.0000
Policy interest rate	-0.2094	-0.4262	0.6699
Real GDP growth rate	0.0316	0.3442	0.7307
Negative interest dummy	-11.268	-8.1914	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.8866	0.8805	147.0483	0.0000

4.2.11. Capital to assets

The Hausman test shows that endogeneity in policy interest rates is an issue in this variable therefore only the 2SLS model results are considered. The redundant fixed effect test

confirmed that the two-way fixed effects specification is correct. Since only 2 outlier observations were removed, the difference between removing and not removing them is small but removing them gives a much higher R-squared therefore there is no reason to further study the impact of those outliers and we just use dataset where they are removed. The difference between removing and not removing countries with only annual data is also small, thus we are using the results from the full sample further on. The results of this regression are shown in table 13, whereas the final coefficient for interest rates is -0.1988 and significant and the coefficient for the negative interest rate beta is 0.7669, and also significant. The R-squared is 0.8741. This indicator will be analysed as a capital adequacy indicator.

Table 13: Capital to assets 2SLS regression results

Variable	Coefficient	T-Statistic	P-value
Constant variable	11.1876	42.6969	0.0000
Policy interest rate	-0.1988	-3.8254	0.0001
Real GDP growth rate	-0.0147	-1.7236	0.0849
Negative interest dummy	0.7668	5.9923	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.8741	0.8675	140.4623	0.0000

5. Discussion of results

In this section, we will provide our conclusions based on the results of the statistical tests and discuss the overall effects of negative interest rates on the indicator groups. Capital to assets will be included in the capital adequacy group as it is the group it is the closest to.

5.1. Capital adequacy

Four indicators are included in the capital adequacy measure group, regulatory capital to risk-weighted assets, tier 1 capital to risk-weighted assets, nonperforming loans net of provisions to capital, and capital to assets. Three of these four yielded significant results in the regressions for policy interest rates and all of them for the negative interest dummy. The one indicator deviating from the rest is nonperforming loans to capital, which in its current form is rather used as an asset quality indicator than a capital adequacy indicator.

The first of these indicators in the regressions results showed that, globally between 2010-2017, higher interest rates lead to higher regulatory capital, or the other way, lower interest rates lead to lower levels of regulatory capital in banks, shown by the positive

significant coefficient value of 0.26. The relationship is, however, not strong, as four percent change in policy interest rates results in one-point change in regulatory capital to risk-weighted assets, but it is significant nonetheless. For negative interest rates, this relationship is even more notable, as the negative interest rate dummy had a coefficient of 3.3, which means that under zero percent interest rates, lower interest rates lead to much lower regulatory capital. This relationship is supported by the results for tier 1 capital to risk-weighted assets, which has basically the same coefficient for the dummy and the policy interest rates.

The results from capital to assets model is different from the previous two, as the interest rate coefficient of -0.2 tells that in general lower interest rates lead to higher capital to asset or financial leverage in other words. This difference can be possibly explained by the different types of capital that is included for this indicator and not included in the stricter regulatory capital indicators. On the other hand, the difference could be based on the difference how risk-weighted assets are calculated, whereas in this indicator assets are calculated without risk-weighting. Nonetheless, the results between capital to assets, and regulatory capital to assets ratios are not entirely consistent. The significant coefficient of 0.77 for the dummy variable implies, however, that there is a breakpoint after which lower interest rates lead to lower financial leverage, which is in line with the other capital adequacy indicators, although the with a different slope.

Overall, these three indicators show some signs that negative interest rates could pose a challenge for banks' capital adequacy, especially at even lower levels than they are at currently. It is important to note, however, that these capital levels are controlled by the Basel Accords and regulatory agencies therefore they cannot drop indefinitely before interception by overseeing agencies. Even if the capital adequacy indicators are over the regulatory limit, the absolute level of capital is not irrelevant, and the results shown above might indicate that negative interest rates and decreasing interest rates in general could be detrimental to banks' capital adequacy and thus stability.

Some quite interesting information is also shown by the cross-section fixed effects intercepts (see Appendix D) , in which we can see that while the average country specific intercept was around 0.14, and the countries that have eventually implemented NIRPs have a -0.84 average country specific intercept, which means that not only is the model coefficient showing that negative interest rates lead to lower capital levels, the intercepts are also showing that these countries have lower ratio of capital to risk-weighted assets. The fixed effects intercepts for Tier 1 capital show the same situation with the overall average intercept at 0.19 and the negative interest rate country intercept at -1.11, again showing that the value

of the ratio is generally lower for these countries. These fixed effects are not modelled, and they probably have sophisticated economic structures behind them, therefore we cannot connect them to policy interest rates, but they still provide some interesting information.

Finally, the last indicator measuring capital adequacy is nonperforming loans to capital, where only the dummy coefficient of 7.37 is significant. This number actually indicates that under zero percent interest rate lower rates lead to lower ratio of NPLs to capital, which in itself would be good since lower NPL ratio is a sign of higher financial stability. Since we know that at those interest rates capital also declined with interest rate, the real decrease in NPLs is much lower than this beta and probably closer to what is given by the regression for NPLs to gross loans (2.5). In general, this indicator – even with context provided by the other capital adequacy indicators – is a weak indicator of capital adequacy, therefore we can only use it for looking at NPL rates, which is an asset quality indicator. The fixed effects country specific intercepts for this indicator show, that while the average intercept for all countries is -0.7, the same value for negative interest rate countries is 28.66. This means that there is an underlying mechanism –that is not modelled by our regressions – which causes NIRP countries to have much higher level of NPL to capital than the global average. This is of course also shown in the descriptive analysis where we showed that these countries have more than twice as high average ratio over the period than the worldwide average. So, while the model coefficient for interest rates is inconclusive, we know that negative interest rate countries have lower level of capital to higher ratio of NPLs.

In conclusion, we have some evidence that indicates that lower interest rates lead to lower capital adequacy in banks not only for negative interest rates, but in general. For negative interest rates this relationship is even magnified which could possibly be a warning that further lowering interest rates could have severe negative side effects on banks' capital adequacy. There is no simple theory linking capital adequacy to interest rates, but interest rates have such an influential effect on banks that it is not unreasonable to assume that unconventional changes in policy interest rates might have ripple effects on banks' capital adequacy. Additionally, our results indicate that banks in negative interest rate countries may have some problems withstanding NPL-related losses in a potential economic downturn, this we will further analyse in the asset quality analysis part.

Overall, we believe that these results are enough to at least bring some attention to banks' capital adequacy in negative interest rate countries. Whether this is strongly related to negative interest rates or a result of some other unmodelled effect is debatable, but the results of our regressions certainly present some evidence that policy interest rates are significant

predictors of capital adequacy. In times of economic growth and stability these problems have a tendency of not manifesting, but lower level of capital coupled with high concentration of NPLs are definitely causes for concern in an economic slump.

5.2. Asset quality

Asset quality is measured by nonperforming loans to gross loans and sectoral distribution of loans. Additionally, nonperforming loans net of provisions to capital is also used in this section as explained before. As it was mentioned at the regression result part, the sectoral distribution of loans indicator gives us nothing useful thus it is not analysed further. The ratio of nonperforming loans is quite a good measure of asset quality. The results of our regressions are not significant for policy interest rates in general, but the dummy variable shows that after removing country specific fixed effects lower interest rates lead to lower NPL to gross loans ratio. This in itself is favourable for countries with NIRPs, but the country specific fixed effects –similarly to the NPL to capital indicator– show that there is an unmodelled structure for which negative interest rate countries have higher proportion of NPLs. In combination with the regression results this makes our results somewhat ambiguous. Therefore, our conclusion regarding asset quality and NPL concentration is that negative interest rates have no noticeable effect in our tests or their effect is positive - as shown by the dummy coefficient - but this effect is balanced out by unmodelled effect shown by the cross-section fixed effects.

Overall, the higher concentration of NPLs might be problematic for banks in these countries especially in an economic downturn, but interest rate changes are not likely to have any negative side effect on these indicators. Theoretically it is possible to tie NPLs to negative interest rates, as lower policy interest rates could lead to lower lending interest rates by banks which in turn increases the lending rates and also removes the profitability constraint of borrowing. This profitability constraint means that if borrowers can get capital without having to pay substantial interest rates, they are not forced to make profits to pay off interests. This mechanism might actually cause a higher concentration of NPLs, but our results give no evidence for this effect. The issue with NPLs however is that they are identified after they turn out to be ‘non-performing’, thus in good economic conditions – and without profitability constraints – they might be underestimated. Based on this theoretical reasoning an economic downturn could be magnified by low asset quality for banks in negative interest rate countries, but our results show no evidence for any adverse side effect by NIRPs.

5.3. Earnings and profitability

The four indicators assessing earnings and profitability are return on assets, return on equity, interest margin to gross income, and noninterest expenses to gross income. Out of the models for these indicators, return on assets and noninterest expenses to gross income gave statistically significant results.

Our regression results for return on assets quite conclusively show that while in general the relationship between interest rates is negative – thus lower interest rates lead to higher ROE – at negative interest rates this relationship is the opposite as lower interest rates lead to lower returns. This suggests that there might be a breakpoint in interest rates where the relationship is changing but whether it is at zero percent or above, our results do not indicate, and they could be a subject of further research in the topic. The country specific fixed effects for ROE also show that the overall average intercept is around 0.088 – as expected, close to zero –, the average intercept for negative interest rate countries is -2.1. This is supported by the descriptive statistics that show that these countries have much lower return on assets on average than the global average. This unmodelled country specific intercept is not related to policy interest rates but combined with the coefficient for the dummy variable they show some signs that return on assets for banks suffered as an adverse side-effect of NIRPs.

The results for return on equity are much less straightforward as they show that the policy interest rate is not a good predictor of return on equity, but the coefficient for the dummy variable is 4.6, which shows that at negative interest rates lower interest rates lead to lower ROE. As we mentioned in the descriptive statistics part, the interpretation of return on equity on a country level is unclear, as the level of return and the level of capital are both equally important parts of the calculation of the indicator, since a higher ratio can be a result of lower leverage thus lower stability. The coefficient for the negative interest rate dummy and the observation that negative interest rate countries have lower capital than the worldwide average supports the results from ROA. Additionally, the country fixed effects for ROE are on average 0.1447 globally, and -11.6 for negative interest rate countries. This leads us to believe that negative interest countries not only have lower returns on average, but lower interest rates genuinely lead to lower returns.

Our results for interest margin to gross income are showing that interest rates in general are not a good predictor for interest margin to gross income, which in reality most likely means that banks adjust their – lending and deposit – interest rates with changes in policy interest rates so that their margins do not change. The negative value for the coefficient of the dummy shows that at negative interest rates lower interest rates lead to higher interest

margins, which means that banks are adjusting their deposit rates more than their lending rates thus widening their margins. This however is complicated by the cross-section fixed effects which are -0.68 on average for all the countries and -2.02 for negative interest rate countries, meaning that there is an unmodelled effect causing these countries to have lower margins. We also showed in our theory section 2.3 that previous research has concluded that interest margins have narrowed in negative interest rate countries, which furthers the uncertainty in our results. Due to the weaknesses in our models and the conflicting results, we are restrained about making conclusions regarding the relationship between interest margins and negative interest rates and rather deem it inconclusive based on our tests. It is possible that interest margins have decreased with reducing interest rates, but gross income has also decreased thus leaving the indicator ratio unchanged. Unfortunately, we do not have the detailed data supporting this hypothesis, but the previous indicators showing decreasing returns show some support for it.

The final measure for profitability, noninterest expenses to gross income is a rather unclear indicator even though our regressions provided significant results. They show that in general higher interest rates lead to lower noninterest expenses as the coefficient is -0.8, or operating expenses in another name, while the same negative connection exists at negative interest rates, only with a higher value of -3.11. The country fixed effects show that banks in negative interest rate countries generally have higher operating expenses, but theoretically connecting this to negative interest rates is difficult as the rate of noninterest expenses depends on the types of banks and many other factors. Therefore, even though we have some significant results for this indicator, we cannot provide any conclusive results for negative interest rates here.

In conclusion for earnings and profitability, we have strong evidence that banks' returns in negative interest rate countries are lower than the global average and also have a significant relationship with the policy interest rates. Theoretically linking interest rates to bank earnings is trivial through interest margins, our regression results, however, did not provide conclusive evidence for narrower interest margins. The way the interest margin indicator is defined there is also the possibility that interest margins for banks in NIRP countries have been narrowed but the ratio with gross income is unchanged. Consequently, we cannot ignore that negative interest rate countries have consistently lower banking returns than the global average and there is reasonable evidence and theory linking this to negative interest rates. The actual mechanism behind this relationship is most likely a combination of different economic processes and we theorize that it is mostly related to interest margins, asset

quality, and changing conditions for banks. The room for further research in this topic is vast, both regarding interest margins and other explanations for the lower returns in negative interest rate countries.

5.4. Liquidity

Liquidity is measured by two indicators, liquid assets to total assets (liquidity ratio), and liquid assets to short-term liabilities. Both of these indicators are crucial in times of economic crises; therefore a lot of attention is given to them by regulators.

The results for liquidity ratio show that policy interest rates are not significant predictors of liquidity. The coefficient of 0.8 for the negative interest dummy signals that under zero percent interest rate lower interest rates lead to lower liquidity in banks. This is supported by the country fixed effects values that are 0.42 on average and -1.85 for countries with NIRPs, the evidence for the positive relationship between interest rates and liquidity is however, weak.

The results for liquid assets to short-term liabilities are also inconclusive, for which the only significant coefficient is -11.27 for the dummy variable. The interpretation of this value is that under a zero percent interest rate lower interest rates lead to higher liquid assets to short-term liabilities meaning that banks can more easily meet the short-term demands for cash. The country fixed effects show that banks in negative interest rate countries have a higher ratio of liquid assets to short-term liabilities, with an average intercept of 0.21 versus the global average of -0.83. This can be a result of higher levels of liquid assets –which goes against the results from liquidity ratio – or banks in these countries have lower short-term liabilities. Nevertheless, results for this indicator certainly do not support our research hypotheses.

Overall, we cannot give any conclusive results regarding the relationship between policy interest rates and liquidity from our tests and it is highly likely that there is no significant relationship. Even if there was some evidence for a relationship, it would be difficult to theoretically link policy interest rates to banking liquidity. Since one goal of negative interest rates is to put more money into the economy by encouraging borrowing money, NIRPs have most likely no adverse side effects on banking stability by our analysis.

6. Conclusions

In this paper, we have studied the adverse side effects of Negative Interest Rate Policies (NIRPs) on banking stability, through the use of regression models between Financial Soundness Indicators (FSIs) and policy interest rates. Our research contributes to the topic of banking stability in NIRP environments, but whereas most research so far only looked at banking profitability closely, we also studied capital adequacy, asset quality, and liquidity. The period we studied was 2010-2017, during which period the countries that have implemented NIRPs are: Denmark (since 2012), the Eurozone (since 2014), Japan (since 2014), Sweden (since 2015), and Switzerland (since 2015).

Our results have shown that there is a statistically significant relationship between NIRPs and capital adequacy. We have shown that countries with NIRPs not only have lower capital adequacy levels in general – which means lower stability – but the NIRPs have likely had an adverse effect on capital adequacy. This combined with the fact that banks in negative interest rate countries have generally worse asset quality – shown by the high levels of nonperforming loans (NPLs) – raises concerns about the capacity of these banks to withstand NPL-related losses in a potential economic downturn. Our results however have not succeeded in linking policy interest rates to NPL indicators, which means that the high ratios of NPLs in negative interest rate countries are probably caused by different factors.

We have also confirmed the outcomes of previous research papers, showing that whereas banks in negative interest rate countries have lower profitability than the global average. Our regression results additionally indicate that negative interest rates directly lead to lower returns during 2010-2017. Although the general theory is that this low profitability is caused by decreased interest margins and competitive pressure between banks in the negative interest economies, our results have shown no support for this theory. This is possibly caused by limitations in our methodology or might indicate that there is some other underlying mechanism behind low profitability. Regarding the fourth group of stability indicators – liquidity – our models provided no significant outcome, which means that we have not found a relationship between policy interest rates and liquidity. Our results regarding profitability and liquidity are rather uncertain and we recommend further research in these areas.

Overall, we believe that these results are reflective of the real economic circumstances in negative interest rate countries, and certainly show that NIRPs have had adverse side-effects on banking stability. It is undeniable, however, that NIRPs have been a successful monetary

tool in reaching inflation targets and stimulating the economies. Thus, we can only echo the conclusions of most research in this topic, which is that the effects of NIRPs on banks have to be continuously studied for signs of severe instability.

Our study comes with certain limitations. First, as shown in our descriptive statistics, the FSI dataset is not entirely reliable, with a high number of outliers. Although we tried to mitigate the issue of incorrect data by running regressions on four different datasets, it is impossible to entirely control for false or even fabricated data with this method. A possible solution for this would be to either analyse the data more carefully – while comparing it to world events – or to use a different dataset. Another limitation arises from the lack of closely related studies in this topic. Studies so far in the field have relied heavily on theory and descriptive methods, with no consensus methodology. We have utilized a straightforward regression model to study the effects of interest rates and negative interest rates on the chosen indicators, which we believe to be adequate to show underlying relationships, but often with ambiguous results. This methodology can be improved by utilizing a more complex model specification, with additional control variables in order to clear away the ambiguity in the results. Additionally, since negative interest rates are relatively recent phenomena, the number of observations in any research will be naturally limited. We tried to overcome this issue by using quarterly data, but this type of data proved to be less reliable, and we also encountered availability issues regarding control variables. A possible solution for this would be to use a smaller dataset, thus both eliminating data from unreliable sources and solving the issue of missing observations. This is a further reason to continuously study this topic in the future with more data available.

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8. Appendix

Appendix A

Hausman test results

Table 14: Regulatory capital to risk-weighted assets Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	16.14034	36.54763	0.0000
Hausman test variable	-0.341141	-3.604919	0.0003
Policy interest rate	0.258249	2.811585	0.0050
Real GDP growth rate	0.018005	1.164800	0.2442
Negative interest dummy	3.153977	14.84009	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.788318	0.777405	72.23653	0.000000

Table 15: Regulatory Tier 1 capital to risk-weighted assets Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	13.79444	31.07631	0.0000
Hausman test variable	-0.319448	-3.351757	0.0008
Policy interest rate	0.242291	2.619143	0.0089
Real GDP growth rate	0.021378	1.373874	0.1696
Negative interest dummy	3.109123	14.51625	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.801574	0.791260	77.72190	0.000000

Table 16: Non-performing loans net of provisions to capital Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	15.04835	3.980221	0.0001
Hausman test variable	-0.520645	-0.659655	0.5095
Policy interest rate	0.701496	0.915719	0.3599
Real GDP growth rate	-0.046351	-0.356946	0.7212
Negative interest dummy	7.118233	3.869671	0.0001
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.739502	0.726060	55.01393	0.000000

Table 17: Non-performing loans to gross loans Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	5.968947	8.241663	0.0000
Hausman test variable	-0.241185	-1.602466	0.1092
Policy interest rate	0.180392	1.234141	0.2173
Real GDP growth rate	0.014235	0.574095	0.5659
Negative interest dummy	2.365033	6.622865	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.751508	0.738672	58.54582	0.000000

Table 18: Return on assets Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	2.371207	12.84087	0.0000
Hausman test variable	0.198022	5.110829	0.0000
Policy interest rate	-0.181310	-4.810577	0.0000
Real GDP growth rate	0.014208	2.340296	0.0193
Negative interest dummy	0.469116	5.574935	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.673633	0.656216	38.67582	0.000000

Table 19: Return on equity Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	15.15234	9.908158	0.0000
Hausman test variable	0.323882	1.021785	0.3070
Policy interest rate	-0.252419	-0.809701	0.4182
Real GDP growth rate	0.076590	1.618747	0.1056
Negative interest dummy	4.764933	7.179283	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.683339	0.666289	40.07844	0.000000

Table 20: Interest margin to gross income Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	60.63700	51.59445	0.0000
Hausman test variable	0.221873	0.906398	0.3648
Policy interest rate	-0.289910	-1.224705	0.2208
Real GDP growth rate	-0.030667	-0.807163	0.4196
Negative interest dummy	-2.987631	-5.565036	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.848599	0.840471	104.4073	0.000000

Table 21: Non-interest expenses to gross income Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	61.64931	45.21042	0.0000
Hausman test variable	0.544226	1.914689	0.0556
Policy interest rate	-0.853708	-3.105855	0.0019
Real GDP growth rate	0.036149	0.819007	0.4129
Negative interest dummy	-2.885757	-4.630640	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.770422	0.758106	62.55693	0.000000

Table 22: Liquid assets to total assets Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	27.03047	34.46774	0.0000
Hausman test variable	0.021051	0.130293	0.8963
Policy interest rate	0.082237	0.524835	0.5997
Real GDP growth rate	0.034519	1.292796	0.1962
Negative interest dummy	0.407534	1.059572	0.2894
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.912378	0.907743	196.8348	0.000000

Table 23: Liquid assets to short-term liabilities Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	63.95285	21.59954	0.0000
Hausman test variable	0.465639	0.763365	0.4453
Policy interest rate	-0.285384	-0.486227	0.6268
Real GDP growth rate	0.024042	0.254298	0.7993
Negative interest dummy	-11.01049	-8.204632	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.886963	0.880889	146.0381	0.000000

Table 24: Capital to assets Hausman test

Variable	Coefficient	T-Statistic	P-value
Constant	11.19902	43.40948	0.0000
Hausman test variable	0.166520	3.122695	0.0018
Policy interest rate	-0.202714	-3.922016	0.0001
Real GDP growth rate	-0.016518	-1.949967	0.0513
Negative interest dummy	0.862206	7.146450	0.0000
R-squared	**Adjusted R-squared**	**F-statistic**	**Prob.(F-statistic)**
0.881324	0.875024	139.8887	0.000000

Appendix B

Redundant fixed effect test results

Table 25: Regulatory capital to risk-weighted assets Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	89.038889	(111,2832)	0.0000
Cross-section Chi-square	4473.934074	111	0.0000
Period F	2.689984	(31,2832)	0.0000
Period Chi-square	86.451327	31	0.0000
Cross-Section/Period F	70.081218	(142,2832)	0.0000
Cross-Section/Period Chi-square	4489.873378	142	0.0000

Table 26: Regulatory Tier 1 capital to risk-weighted assets Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	95.652545	(111,2809)	0.0000
Cross-section Chi-square	4624.356903	111	0.0000
Period F	3.189078	(31,2809)	0.0000
Period Chi-square	102.246122	31	0.0000
Cross-Section/Period F	75.346245	(142,2809)	0.0000
Cross-Section/Period Chi-square	4642.297201	142	0.0000

Table 27: Non-performing loans net of provisions to capital Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	61.770503	(110,2810)	0.0000
Cross-section Chi-square	3633.142266	110	0.0000
Period F	1.227415	(31,2810)	0.1809
Period Chi-square	39.758271	31	0.1346
Cross-Section/Period F	49.325451	(141,2810)	0.0000
Cross-Section/Period Chi-square	3682.019213	141	0.0000

Table 28: Non-performing loans to gross loans Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	71.030206	(110,2807)	0.0000
Cross-section Chi-square	3929.418594	110	0.0000
Period F	1.449036	(31,2807)	0.0520
Period Chi-square	46.882403	31	0.0336
Cross-Section/Period F	56.060977	(141,2807)	0.0000
Cross-Section/Period Chi-square	3954.689360	141	0.0000

Table 29: Return on assets Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	37.879106	(110,2717)	0.0000
Cross-section Chi-square	2661.525562	110	0.0000
Period F	1.740240	(31,2717)	0.0069
Period Chi-square	56.289349	31	0.0036
Cross-Section/Period F	29.919164	(141,2717)	0.0000
Cross-Section/Period Chi-square	2683.030519	141	0.0000

Table 30: Return on equity Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	43.857137	(110,2693)	0.0000
Cross-section Chi-square	2914.373275	110	0.0000
Period F	1.894048	(31,2693)	0.0021
Period Chi-square	61.233602	31	0.0010
Cross-Section/Period F	34.558093	(141,2693)	0.0000
Cross-Section/Period Chi-square	2932.595845	141	0.0000

Table 31: Interest margin to gross income Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	127.409269	(110,2701)	0.0000
Cross-section Chi-square	5189.356264	110	0.0000
Period F	1.300254	(31,2701)	0.1241
Period Chi-square	42.172761	31	0.0870
Cross-Section/Period F	100.258679	(141,2701)	0.0000
Cross-Section/Period Chi-square	5209.967021	141	0.0000

Table 32: Non-interest expenses to gross income Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	78.788138	(110,2703)	0.0000
Cross-section Chi-square	4092.842720	110	0.0000
Period F	1.378844	(31,2703)	0.0796
Period Chi-square	44.700449	31	0.0530
Cross-Section/Period F	62.949778	(141,2703)	0.0000
Cross-Section/Period Chi-square	4144.793074	141	0.0000

Table 33: Liquid assets to total assets Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	240.400886	(110,2741)	0.0000
Cross-section Chi-square	6828.723307	110	0.0000
Period F	1.123541	(31,2741)	0.2921
Period Chi-square	36.453869	31	0.2298
Cross-Section/Period F	188.122158	(141,2741)	0.0000
Cross-Section/Period Chi-square	6836.737258	141	0.0000

Table 34: Liquid assets to short-term liabilities Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	193.017213	(104,2587)	0.0000
Cross-section Chi-square	5917.964203	104	0.0000
Period F	2.231768	(31,2587)	0.0001
Period Chi-square	71.970724	31	0.0000
Cross-Section/Period F	148.985688	(135,2587)	0.0000
Cross-Section/Period Chi-square	5922.686793	135	0.0000

Table 35: Capital to assets Redundant fixed effect test

Effects Test	Statistic	Degree of freedom	Prob.
Cross-section F	159.504771	(106,2656)	0.0000
Cross-section Chi-square	5587.171317	106	0.0000
Period F	2.711386	(31,2656)	0.0000
Period Chi-square	87.174534	31	0.0000
Cross-Section/Period F	124.305524	(137,2656)	0.0000
Cross-Section/Period Chi-square	5604.615653	137	0.0000

Appendix C

Table 36: Cross-section fixed effects

COUNTRY(*)	Regulatory capital to risk-weighted assets	Regulatory Tier 1 capital to risk-weighted assets	Non-performing loans net of provisions to capital	Capital to assets	Non-performing loans to total gross loans	Return on assets	Return on equity	Interest margin to gross income	Non-interest expenses to gross income	Liquid assets to total assets	Liquid assets to short-term liabilities
Afghanistan, Islamic Republic of	2.90	4.65	-21.26	1.87	1.85	0.49	-10.84	0.50	24.54	33.03	17.15
Albania	-0.73	-0.27	23.64	-1.60	13.79	-1.05	-6.36	27.75	2.67	-16.47	-49.14
Angola	-5.43	-3.37	-23.12	0.15	-2.59	2.66	12.70	-3.57	-2.81	6.49	-17.16
Argentina	-6.36	-5.31	-33.07	4.91	-8.09	6.84	36.87	-19.01	2.65	2.70	-11.23
Armenia, Republic of	0.40	0.73	-3.37	7.29	-1.50	0.32	-5.91	5.00	1.21	-0.10	76.61
Australia	-4.38	-3.77	-3.53	-4.93	-5.00	-0.73	5.85	7.88	-9.66	-10.80	-22.80
Austria	**-1.01**	**-2.37**	**-8.40**	**-4.10**	**-4.11**	**-2.35**	**-14.05**	**2.00**	**19.17**	**-2.36**	**12.81**
Belarus	-3.75	-4.91	-13.77	7.10	-4.78	4.06	6.98	-40.13	51.26	2.00	36.96
Belgium	**0.36**	**0.08**	**1.12**	**-5.47**	**-3.84**	**-2.08**	**-9.35**	**0.71**	**7.57**	**6.75**	**8.65**
Bhutan	0.28	-0.79	-6.22	4.96	1.91	-1.09	-11.99	26.48	-23.93	-5.20	-10.52
Bolivia	-2.82	-1.73	-18.88	-2.90	-4.62	-0.57	2.64	12.43	11.35	4.64	1.08
Bosnia and Herzegovina	-1.41	-1.18	10.18	3.99	5.51	-0.43	-8.19	3.40	29.16	-1.34	-17.05
Botswana	1.45	-2.69	-13.94	-1.78	-4.17	1.72	12.81	4.74	-2.17	-10.71	-41.96
Brazil	-2.30	-3.40	-33.86	0.71	-4.58	1.11	2.19	18.23	-0.10	-15.21	132.92
Brunei Darussalam	2.74	5.84	-14.47	1.44	-2.93	0.14	-0.70	16.30	-9.48	22.20	43.69
Burundi	1.26	1.47	-16.33	5.12	3.96	1.69	1.77	-3.46	10.33	-8.97	-23.57
Cambodia	8.32	9.13	-12.21	5.68	-3.69	0.35	-1.96	6.03	-2.78	-10.37	-39.49
Cameroon	-8.44	-6.94	-8.52	-2.96	3.66	0.11	10.66	-37.20	24.83	-2.28	89.29
Canada	-1.52	-1.55	-8.69	-6.16	-5.38	-1.15	7.31	-9.80	2.15	-14.66	-15.88
Central African Republic	12.69	13.63	-0.19	10.74	11.96	0.90	-0.33	-5.58	10.36	-2.32	
Chad	-1.41	-0.65	-0.30	1.85	3.42	1.01	8.12	-8.79	1.99	3.92	91.37
Chile	-3.59	-4.53	-18.82	-2.42	-4.39	-0.23	4.48	5.83	-10.09	-14.94	
China, P.R.: Hong Kong	0.70	0.05	-13.82	-2.12	-5.35	-1.27	0.11	-14.66	-12.13	-5.10	23.83
China, P.R.: Macao	-1.50	-2.35	-14.73	-7.07	-5.97	-1.51	7.51	10.50	-23.62	9.56	-3.08
Colombia	0.33	-2.05	-25.14	4.55	-3.65	1.63	7.50	-2.03	-13.51	-6.72	-20.12

COUNTRY(*)	Regulatory capital to risk-weighted assets	Regulatory Tier 1 capital to risk-weighted assets	Non-performing loans net of provisions to capital	Capital to assets	Non-performing loans to total gross loans	Return on assets	Return on equity	Interest margin to gross income	Non-interest expenses to gross income	Liquid assets to total assets	Liquid assets to short-term liabilities
Comoros	9.63	10.89	9.04		12.66	-2.13	-15.05	-7.45	10.30	10.71	
Costa Rica	-0.30	-1.64	-19.55	-0.27	-5.08	-0.34	-5.70	0.46	9.62	2.68	61.27
Croatia	3.29	4.34	15.37	3.82	6.90	-0.50	-7.51	6.06	11.67	5.39	-12.69
Cyprus	**-3.69**	**-2.30**	**161.13**	**-3.32**	**22.53**	**-3.03**	**-24.32**	**18.43**	**-4.87**	**-3.38**	**-25.14**
Czech Republic	0.18	1.82	7.16	-4.24	-0.84	-1.06	3.41	0.58	-14.65	3.32	1.72
Denmark	**0.21**	**0.64**	**6.64**	**-5.17**	**-3.75**	**-2.41**	**-13.87**	**10.39**	**22.17**	**-13.67**	**-0.70**
Djibouti	-8.70	-1.16	51.87	-4.37	7.98	1.25	10.46	12.73	11.94	35.96	65.63
Dominican Republic	-0.18	0.10	-24.00	-0.43	-4.78	0.55	3.27	10.86	9.32	3.35	
Ecuador	0.29	1.44	-20.81	3.37	-3.49	0.32	-4.28	-11.02	-10.50	-7.24	-27.71
El Salvador	0.40	-0.25	-19.24	3.15	-3.77	-0.51	-5.24	12.88	-0.28	-9.26	-36.83
Equatorial Guinea	5.46	8.12	2.73	1.47	5.54	0.46	4.51	-6.09	-14.33	15.27	
Estonia	**8.34**	**9.39**	**-4.94**	**-1.24**	**-4.55**	**-0.58**	**-2.12**	**-8.08**	**-10.49**	**-7.57**	**-31.82**
Fiji	0.06	-0.17	-5.07	-1.87	-3.11	0.42	8.13	-2.31	-5.43	-8.71	15.77
Finland	**-0.07**	**-15.28**	**-10.10**	**-6.13**	**-6.95**	**-2.03**	**-7.26**	**-16.93**	**0.98**	**-14.56**	**-32.05**
France	**-2.35**	**-2.28**	**0.31**	**-6.19**	**-3.03**	**-2.11**	**-9.00**	**-21.69**	**10.26**	**14.41**	**-5.81**
Gabon	-2.67	-0.36	-14.94	0.75	-2.67	0.69	7.61	-12.24	8.46	-2.30	76.27
Gambia, The	7.26	8.98	-15.74	6.63	3.56	3.24	5.90	-3.72	26.60	26.62	18.72
Georgia	-0.20	-1.75	-12.55	7.54	-1.37	0.79	-2.42	3.07	6.80	-1.66	-18.02
Germany	**-0.05**	**-0.94**		**-6.29**						**17.13**	**84.17**
Ghana	-3.44	-2.86	-14.28	6.52	5.86	5.70	14.06	-7.07	-0.17	21.79	5.55
Greece	**-4.28**	**-2.26**	**89.44**	**-3.46**	**20.18**	**-3.03**	**-25.51**	**23.37**	**-1.77**	**3.20**	**-16.97**
Guatemala	-2.36	-3.82	-15.41	-3.26	-5.22	0.25	5.77	16.28	4.53	2.30	-34.12
Guinea	-1.54	0.67	-17.53	2.75	-2.14	2.22	7.86	-29.20	34.19	2.91	-11.60
Honduras	-2.78	-5.35	-23.21	0.59	-3.64	1.00	8.60	-8.32	-6.67	0.43	-19.13
Hungary	-0.95	-1.24	20.31		5.86	-1.35	-9.97	-8.20	21.45	3.52	-9.03
India	-4.91	-5.57	-1.01	-2.72	-2.48	-0.39	-3.11	8.93	-6.55	-18.77	-35.04
Indonesia	1.80	2.96	-14.09	3.16	-4.85	1.41	7.06	7.45	-8.50	-3.88	-29.47

COUNTRY(*)	Regulatory capital to risk-weighted assets	Regulatory Tier 1 capital to risk-weighted assets	Non-performing loans net of provisions to capital	Capital to assets	Non-performing loans to total gross loans	Return on assets	Return on equity	Interest margin to gross income	Non-interest expenses to gross income	Liquid assets to total assets	Liquid assets to short-term liabilities
Ireland	**3.58**	**3.59**	**46.38**	**-1.95**	**10.87**	**-2.43**	**-18.19**	**-5.69**	**5.93**		
Israel	-2.11	-4.51	-8.79	-4.04	-3.66	-1.13	-0.95	-0.40	7.23	-13.14	-37.36
Italy	**-3.62**	**-4.14**	**59.00**	**-5.82**	**7.73**	**-2.53**	**-17.58**	**-7.99**	**1.59**	**-12.26**	**34.67**
Japan	**-1.85**	**-2.51**	**-0.17**	**-6.11**	**-4.63**	**-2.22**	**-9.65**	**5.44**	**2.14**	**-0.79**	**-12.54**
Kazakhstan	-1.11	-2.07	16.29	2.70	8.79	1.38	4.02	3.61	-13.13	-5.82	1.45
Kenya	2.22	2.33	-1.07	5.70	-2.09	4.02	19.20	6.90	-1.88	7.07	-22.95
Korea, Republic of	-2.36	-2.82	-13.87	-2.56	-5.79	-1.15	-5.07	12.01	-0.87	9.59	53.86
Kosovo, Republic of	-0.30	-0.75	-14.66	-0.77	-0.93	-1.21	-5.05	8.15	-2.76	4.58	14.35
Kyrgyz Republic	10.10	8.97	-11.05	10.10	2.00	0.03	-7.02	1.21	13.00	6.36	13.95
Latvia	**0.72**	**0.53**	**-2.49**	**-1.35**	**-0.21**	**-1.52**	**-7.05**	**-5.60**	**-5.90**	**7.20**	**-5.53**
Lebanon	-4.92	-3.50	-17.12	-1.12	-4.01	0.60	1.93	5.67	-2.59	-7.01	-30.28
Lesotho	-1.97	-0.39	-16.47	1.38	-4.39	3.37	29.04	-2.21	0.81	11.00	3.78
Lithuania	**0.48**	**1.62**	**36.91**	**-0.91**	**5.35**	**-1.56**	**-8.34**	**-10.08**	**0.18**	**-5.12**	**-28.11**
Luxembourg	**2.50**	**3.38**	**-12.26**	**-5.14**	**-5.83**	**-1.87**	**-6.87**	**-30.48**	**6.03**	**31.57**	**8.84**
Macedonia, FYR	-0.70	-0.47	-19.83	0.76	2.90	-1.04	-8.08	3.52	5.81	-2.06	-20.23
Madagascar	-3.63	-0.30	0.04	1.09	2.09	2.65	19.72	1.77	6.27	9.77	-5.38
Malaysia	-0.60	-1.12	-8.22	-0.72	-4.44	-0.54	-0.43	-1.77	-14.53	-11.42	4.21
Maldives	21.72	18.32	-12.67	10.49	7.84	2.92	5.69	2.95	-28.60	8.62	-14.24
Malta	**-2.18**	**-3.01**	**17.69**	**-4.06**	**0.02**	**-1.36**	**-1.02**	**7.05**	**-9.74**	**-2.16**	**-13.94**
Mauritius	-0.12	0.40	-5.47	-1.36	-2.47	-0.21	1.90	7.11	-16.68	-5.06	-32.09
Mexico	-1.42	-0.81	-25.14	0.16	-4.21	0.25	3.43	11.67	-6.21	9.22	-13.78
Moldova	7.52	9.38	-0.61	6.72	6.15	0.72	-2.95	-3.12	4.01	4.93	17.09
Namibia	-3.00	-3.61	-11.59	1.04	-5.61	1.90	18.13	-3.66	-1.62	-15.69	-41.53
Netherlands	**-0.51**	**-1.11**	**23.57**	**-6.63**	**-4.29**	**-2.11**	**-8.12**	**13.68**	**13.77**	**-4.04**	**111.59**
Nigeria	-5.04	-2.68	9.13	0.27	1.70	1.90	9.38	2.47	10.08	-13.51	-40.52
Norway	**-0.38**	**0.05**	**-7.50**		**-4.85**	**-1.11**	**-2.56**	**-24.06**	**8.37**	**-16.73**	**-37.49**
Pakistan	-3.02	-3.12	-5.65	-1.65	5.44	0.57	1.32	13.87	-1.26	14.84	16.17

COUNTRY(*)	Regulatory capital to risk-weighted assets	Regulatory Tier 1 capital to risk-weighted assets	Non-performing loans net of provisions to capital	Capital to assets	Non-performing loans to total gross loans	Return on assets	Return on equity	Interest margin to gross income	Non-interest expenses to gross income	Liquid assets to total assets	Liquid assets to short-term liabilities
Panama	-0.75	1.05	-9.81	-0.25	-3.90	-0.83	-1.79	-6.65	-11.58	-10.88	-23.20
Papua New Guinea	13.26	8.21	-16.47	1.67	-4.85	4.18	34.59	-3.25	-12.58	-10.09	-39.28
Paraguay	-1.64	-3.57	-17.86	-2.83	-4.92	1.25	13.00	-49.46	-25.98	-17.49	-37.72
Peru	-2.65	-3.81	-23.19	-0.12	-3.22	0.35	6.11	26.19	-9.68	-1.80	-20.98
Philippines	-0.46	-0.87	-14.47	0.34	-4.20	-0.11	1.25	4.15	-0.82	9.59	-5.66
Poland	-1.58	-0.61	-5.83	-1.63	-1.78	-0.90	-2.78	-3.66	-2.04	-6.28	-31.97
Portugal	**-5.43**	**-4.24**	**31.89**	**-5.17**	**4.16**	**-2.65**	**-18.91**	**-8.28**	**3.08**	**-17.32**	**-43.20**
Romania	-0.59	0.19	3.25	-1.89	7.55	-1.28	-10.50	0.04	0.08	29.38	88.72
Russian Federation	-4.03	-5.15	-6.82	1.53	0.52	0.81	-0.50	-20.18	17.24	-2.82	44.43
Rwanda	6.80	6.88	2.08	5.40	-0.47	1.50	-0.23	-4.92	7.16	6.08	
San Marino	**-4.02**	**-1.31**	**210.72**	**-3.52**	**24.52**	**-3.39**	**-26.72**	**-7.68**	**4.10**	**1.70**	**0.92**
Saudi Arabia	1.68	2.13	-18.39	2.18	-4.25	-0.25	-0.43	6.71	-17.97	-5.86	-30.84
Seychelles	5.10	3.07	-7.57	0.61	-0.71	2.72	20.26	1.27	-3.86	29.70	4.27
Singapore	0.29	0.10	-9.97	-2.18	-5.02	-0.92	-0.18	-0.05	-18.89	42.86	13.30
Slovak Republic	**-1.38**	**-0.34**	**-5.09**	**-0.53**	**-2.26**	**-1.32**	**-6.17**	**17.99**	**-1.07**	**8.47**	**-8.94**
Slovenia	**-2.81**	**-1.79**	**31.39**		**3.57**	**-2.49**	**-15.67**	**-0.28**	**6.83**	**-6.24**	**-9.44**
South Africa	-2.66	-1.53	5.33	-2.46	-3.06	0.16	6.25	-9.07	-0.01	-10.80	-29.11
Spain	**-4.65**	**-4.16**	**5.62**	**-4.74**	**-1.11**	**-2.24**	**-12.66**	**4.31**	**-9.98**	**-14.18**	**-35.46**
Sri Lanka	-2.08	-1.78	-3.01	-1.24	-2.80	0.78	9.79	10.47	-6.12	2.27	-19.31
Swaziland	4.86	4.42	-0.50	2.93	0.13	3.32	15.94	-8.93	1.87	-18.74	-48.83
Sweden	**1.95**	**2.02**	**-11.75**	**-6.80**	**-6.50**	**-1.78**	**-1.82**	**-2.92**	**-8.21**	**-12.67**	**50.32**
Tajikistan	5.08	5.03	-4.51	8.87	4.63	-0.06	-7.63	-17.41	14.13	-2.58	18.54
Tanzania	-0.70	1.38	-5.79	1.64	-1.39	2.10	9.02	6.65	12.64	9.62	-18.16
Thailand	-0.31	-1.63	-6.66	-1.72	-3.37	-0.44	-1.15	2.66	-11.40	-7.88	-31.94
Trinidad and Tobago	6.70	6.73	-8.77	3.51	-1.96	0.68	2.99	-0.71	-3.78	-1.18	-29.86
Turkey	-0.96	-0.72	-15.96	1.51	-4.06	0.86	5.13	6.11	-11.30	22.70	10.22
Uganda	2.10	2.10	-18.53	4.68	-4.17	4.34	14.92	9.16	8.14	1.23	-11.04

COUNTRY(*)	Regulatory capital to risk-weighted assets	Regulatory Tier 1 capital to risk-weighted assets	Non-performing loans net of provisions to capital	Capital to assets	Non-performing loans to total gross loans	Return on assets	Return on equity	Interest margin to gross income	Non-interest expenses to gross income	Liquid assets to total assets	Liquid assets to short-term liabilities
Ukraine	-2.86	-4.66	28.81	4.14	10.46	-2.27	-23.56	-0.75	9.24	-2.90	29.35
United Arab Emirates	2.88	2.14	-7.74		-0.00	-0.35	-3.32	8.37	-23.34	-14.24	-33.08
United Kingdom	1.90	0.93	-6.56	-5.10	-3.74	-1.96	-9.28	-13.97	5.85	-5.84	-24.26
United States	-1.72	-0.96	-2.76	0.93	-3.33	-2.00	-12.63	2.82	0.00	-13.79	16.11
Uzbekistan	5.03	5.52	-22.79	2.63	-7.71	1.54	4.51	-20.32	9.18	3.43	12.21
Zambia	4.44	4.55	-14.76	1.97	2.04	2.75	14.34	-8.76	4.01	11.29	-12.61

(*): *Negative interest rate policy countries are in bold*

Appendix D

Table 37: Average cross-section fixed effects

COUNTRY	Regulatory capital to risk-weighted assets	Regulatory Tier 1 capital to risk-weighted assets	Non-performing loans net of provisions to capital	Capital to assets	Non-performing loans to total gross loans	Return on assets	Return on equity	Interest margin to gross income	Non-interest expenses to gross income	Liquid assets to total assets	Liquid assets to short-term liabilities
Overall	0.14	0.19	-0.70	0.10	-0.15	0.09	0.14	-0.68	0.88	0.42	-0.83
NIRP	-0.84	-1.11	28.66	-4.28	1.87	-2.10	-11.60	-2.02	2.61	-1.85	0.21

Appendix E

Table 38: Correlation matrix

	Return on Equity	Return on Asset	Regulatory Tier 1 capital to risk-weighted assets	Regulatory capital to risk-weighted assets	Non-performing loans to total gross loans	Non-performing loans net of provisions to capital	Non-interest expenses to gross income	Liquid assets to total assets	Liquid assets to short-term liabilities	Interest margin to gross income	CPI growth rate	Real GDP growth rate	Policy interest rate	Capital to assets
Return on Equity	1.00	0.87	0.08	0.13	-0.36	-0.37	-0.38	0.01	-0.14	-0.20	0.14	0.13	0.26	0.02
Return on Asset	0.87	1.00	0.29	0.34	-0.23	-0.33	-0.35	0.05	-0.15	-0.20	0.19	0.11	0.40	0.34
Regulatory Tier 1 capital to risk-weighted assets	0.08	0.29	1.00	0.90	0.08	-0.12	-0.06	0.25	-0.03	-0.05	0.04	-0.01	0.23	0.61
Regulatory capital to risk-weighted assets	0.13	0.34	0.90	1.00	-0.01	-0.20	-0.10	0.17	-0.07	-0.09	0.05	0.02	0.21	0.61
Non-performing loans to total gross loans	-0.36	-0.23	0.08	-0.01	1.00	0.78	0.12	0.10	0.00	0.05	-0.03	-0.10	0.08	0.13
Non-performing loans net of provisions to capital	-0.37	-0.33	-0.12	-0.20	0.78	1.00	0.12	-0.05	-0.04	0.04	-0.10	-0.12	-0.15	-0.17
Non-interest expenses to gross income	-0.38	-0.35	-0.06	-0.10	0.12	0.12	1.00	0.01	0.20	-0.07	0.05	-0.09	0.06	-0.05
Liquid assets to total assets	0.01	0.05	0.25	0.17	0.10	-0.05	0.01	1.00	0.36	0.03	0.05	0.04	0.26	0.08
Liquid assets to short-term liabilities	-0.14	-0.15	-0.03	-0.07	0.00	-0.04	0.20	0.36	1.00	0.00	0.01	-0.03	0.11	-0.02
Interest margin to gross income	-0.20	-0.20	-0.05	-0.09	0.05	0.04	-0.07	0.03	0.00	1.00	-0.17	0.02	-0.28	-0.04
CPI growth rate	0.14	0.19	0.04	0.05	-0.03	-0.10	0.05	0.05	0.01	-0.17	1.00	0.00	0.45	0.13
Real GDP growth rate	0.13	0.11	-0.01	0.02	-0.10	-0.12	-0.09	0.04	-0.03	0.02	0.00	1.00	0.02	0.02
Policy interest rate	0.26	0.40	0.23	0.21	0.08	-0.15	0.06	0.26	0.11	-0.28	0.45	0.02	1.00	0.35
Capital to assets	0.02	0.34	0.61	0.61	0.13	-0.17	-0.05	0.08	-0.02	-0.04	0.13	0.02	0.35	1.00