Negative Interest Rates and Corporate Tax Behavior in Banks

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Abstract

This study examines the impact of negative interest rate regimes on corporate tax behavior. We argue that negative interest rates act as a *de-facto* tax levied by central banks on banks and investigate how this 'tax' affects banks' corporate tax planning. Using a sample of domestic banks in OECD countries and a difference-in-difference research design, we find that banks affected by negative interest rate policies experience an increase in tax planning when and after the policy is adopted, compared to unaffected banks. Our primary analysis shows that the introduction of a negative interest rate is associated with an approximate 2.3 to 2.6 percentage point decrease in *GAAP ETR* and that the effects of negative interest rates are more pronounced in banks with a lower distance to default, in banks with lower reserves, and in countries with lower levels of tax enforcement. Collectively, our results suggest that negative interest rates lead banks to increase tax planning as a funding source, especially for financially constrained banks.

Negative Interest Rates and Corporate Tax Behavior of Banks

1. Introduction

This study examines the effect of negative interest rates on the corporate tax planning behavior of banks.[1] While long considered only to be a theoretical possibility, there is an increasing global trend towards the use of negative interest rates. This trend is likely to persist given that interest rates remain at, or near, historically low levels for many countries (Del Negro et al., 2019). Negative interest rates affect the cost of funds available to banks because instead of generating interest revenue on excess reserves, banks are charged a fee on their excess reserves by central banks. In this sense, negative interest rates force banks to bear additional costs while managing the trade-off between their liquidity requirements and the opportunity cost of holding excess reserves.[2]

By charging a fee to banks, the Central Bank disincentivizes banks from holding cash, which in turn should encourage lending at lower rates. The underlying rationale for the implementation of a negative interest rate regime is that it incentivizes debtors (creditors) to borrow (save) more (less) and stimulate the economy through increased spending until negative interest rates are no longer needed. Given that central banks are wholly owned subsidiaries of the government, their operating results revert back to the treasury. Therefore, negative interest rates serve as a *de-facto* tax levied by the central bank on banks. In theory this 'tax' can be borne by

[1] Our study examines a variety of credit institutions, which we refer to collectively as "banks". We expect the incentives and behavior we study to be relatively consistent across different deposit holding and lending institutions. Our sample includes: Bank holdings & holding companies, Commercial banks, Cooperative banks, Finance companies, Investment & Trust corporations, Investment banks, Other non-banking credit institutions, Private banking/Asset management companies, Real Estate & Mortgage banks, Savings banks, and Securities firms.

[2] Excess reserves represent bank deposits at the Federal Reserve that are above what the bank is legally required to hold to back their checkable deposits.

shareholders through lower after-tax profits/higher risk, by depositors through lower interest rates, or by borrowers through higher interest rates and/or fees.

While Central Banks can employ many different monetary tools to achieve policy, negative interest rates have become increasingly prominent.[3] As of August 2019, 25% of all government bonds ($15 trillion) world-wide, have negative interest rates and this number has tripled since October 2018 (Fitzgerald, 2019). Since 2014, many central banks, including the Danmarks National Bank (DNB), the European Central Bank (ECB), the Swiss National Bank (SNB), the Swedish Riks Bank, and the Bank of Japan (BoJ) have reduced their policy rates to below zero. While the primary reason for negative interest rates has been to stabilize inflation expectations and generate increases in economic growth, negative interest rates have been utilized in some jurisdictions, such as Switzerland and Denmark, to reduce currency appreciation.

The academic literature has largely focused on the concept of a zero lower bound for interest because, in theory, a depositor could always store physical currency to avoid negative interest rates (Bech and Malkhozov, 2016). In a similar vein, banks, at least in theory, could choose to reduce their excess capital reserves to zero to avoid negative interest rate penalties. While banks are heavily regulated, Basel III requires commercial and depository banks to meet certain minimum capital requirements. Following the 2007-2008 financial crisis, many central banks, including those in the U.S., Europe, and Japan, began paying interest on excess reserves to disincentivize reserve avoidance and to encourage banks to hold more reserves. In response, capital reserves have increased dramatically. As an example, U.S. commercial banks' capital reserves increased from $1.9 billion in August 2008 to $2.6 trillion in January 2015 (Craig and Koepke,

[3] Central banks have three tools of monetary policy: open market operations, reserve requirements, and the discount rate. Central Bank chooses monetary policy in accordance to how well it can implement it.

2015)[4]. Given the large size of capital reserves, negative interest rates would be expected to have a material impact on banks' business operations.

To examine how negative interest rate policies affects banks' income tax planning behavior, we employ a sample of domestic banks from OECD countries, where a number of countries have implemented negative interest rate regimes, and exploit the staggered introduction of those negative interest rate policies in specific countries during the 2010s.[5] Using a difference-in-difference research design, our primary analysis documents that the introduction of a negative interest rate regime is associated with an approximate 2.3 to 2.6 percentage point decrease in GAAP effective tax rates.

These findings are robust to a number of alternative specifications. Importantly, despite the staggered adoption of negative interest rates, when we align the event time of negative interest rate policy adoptions, a parallel trend exists between our treatment and control groups. Additionally, our results are not driven by a specific country and remain both negative and significant with the inclusion of U.S. banks to our control group and with the exclusion of Japanese banks (who underwent a tax reform in 2016) to our treatment group. Our results are also stronger when we remove the negative interest rate implementation year for each country to allow banks more time to adjust their tax planning. The inferences also remain unchanged when additional tax planning variables (i.e., loan loss provisions and off-balance sheet items) are added as control variables, and when we propensity score match our treated firms based on size, profitability (*ROAE*), equity ratio, and liquidity. In a falsification test, using 0.05% as the pseudo introduction of a negative interest

[4] See https://fred.stlouisfed.org/series/EXCSRESNS for the excess Reserves of Depository Institutions. In May 2020, excess reserves plateaued at $3.2 trillion.

[5] Our sample includes only domestic banks because multinational banks may operate in countries with both negative and positive interest rate regimes.

rate regime, we do not observe a significant effect. This provides comfort that our findings are not an artifact of our research design.

We also perform a number of cross-sectional analyses. Specifically, we provide evidence that the effect of negative interest rate policies on tax planning is concentrated on banks with greater financial constraints, as evidenced through banks with a lower distance to default and banks with lower reserves. We also document that the effect is concentrated in countries with lower levels of tax enforcement which suggests that banks in these countries are better able to reduce their income tax payments when faced with negative interest rates.

This paper contributes to the literature in several ways. First, to the best of our knowledge, this is the first paper investigating the effect of negative interest rates on banks' corporate tax behavior. While answering the call for more research on the taxation of financial institutions (Hanlon and Heitzman, 2010), we show that monetary policy is an important determinant for banks' tax planning (Scholes et al., 1990). Consistent with our argument that negative interest rates are *de-facto* taxes, we also contribute to the broader literature on the effect of various forms of taxation on banks (Andries et al., 2017; de Mooij et al., 2015; Keen and Mooij, 2012; Schepens, 2016).

Second, we contribute to the literature on the effect of government economic interventions on banks. Our study complements recent work examining the introduction of bank-specific levies and their impact on the behavior of those banks (Buch et al., 2016; Capelle-Blancard and Havrylchyk, 2017; Devereux et al., 2019; Kogler, 2019). While negative interest rates increase the banks' funding cost, our results suggest that banks internalize some of the increased costs and adjust their corporate taxes to increase internally generated funds.

Finally, our results should be of interest to policymakers considering the implementation of negative interest rate regimes. Highlighting the potential broadening of these types of policies,

in response to the current Coronavirus Pandemic, the U.S. Federal Reserve's key rate has been set near zero, at 0.25%. While negative interest rates are widely considered as a measure of last resort, after all other stimulus tools have been exhausted, given persistently low interest rates, many countries could consider the adoption of this monetary tool (Buchanan and Dorf, 2016). By showing the spillover effect of this monetary policy tool on bank corporate tax behavior, this study adds to the on-going discussion about the consequences of negative interest rates.

The remainder of this paper is structured as follows: Section 2 provides background information and develops our hypothesis; Section 3 describes the data and outlines the empirical design; Sections 4 and 5 present the empirical results and a discussion of the findings; and Section 6 concludes.

2. Background and Hypothesis Developments

2.1 Financial Institutions and Tax Planning

Following Dyreng et al. (2008), many studies have examined the determinants and consequences of corporate tax avoidance. Determinants include a variety of firm-specific characteristics, incentives and constraints, and executive characteristics (see Wilde and Wilson 2018 for a review.) However, despite the large tax planning literature, little is known about the banking industry because most studies remove the financial service sector from cross-industry samples. The arguments frequently presented for their exclusion are that financial firms can bias the results given that they have high leverage (Fama and French, 1992) and substantial regulatory differences (Hanlon and Heitzman, 2010). While this design choice in the study of broad research questions related to taxation has merit, it leaves the examination of the impact of taxation on financial institutions as a potentially understudied area. Hanlon and Heitzman (2010) specifically make a call for additional research on the taxation of financial institutions.

Notwithstanding the above, given the incentives they face, banks, like non-financial firms, should consider income taxes in their decision making. Scholes et al. (1990) document evidence that banks trade-off tax and non-tax factors in making their investment and financing decisions. In support of this notion, Merz and Overesch (2016) document that the reported earnings of multinational banks' subsidiaries significantly respond to host country tax incentives. Their study finds that the tax response of reported profitability is even more pronounced than for MNCs in other industries, which indicates that multinational banks have large tax-planning opportunities.

While some prior literature documents evidence of international profit shifting by multinational banks (Demirgüç-Kunt and Huizinga, 1999, 2001), recent studies explore how banks adjust their behavior in response to the introduction of tax transparency instruments. Joshi et al. (2020) utilize the introduction of mandatory EU country-by-country tax disclosures for financial institutions to find a meaningful decrease in the profit shifting activities of financial subsidiaries after the reform but no change to the overall tax avoidance. On the contrary, Overesch and Wolff, (2021) find that multinational banks increase their tax expense relative to other banks unaffected by the Country-by-Country Reporting mandate.

2.2 Taxes on the Financial Sector

Shackelford et al. (2010) note that before the 2007-2008 financial crisis, regulation, instead of specific tax policy instruments, was used to address financial sector issues.[6] However, in the aftermath of the crisis, many countries began to reform taxation so that governments could collect the high cost associated with banking interventions and to internalize commercial banks' contribution to systemic economic risk.

[6] The tax system can act as a substitute for banking regulations and change banks' behaviours. For example, banks' loan loss provisions are positively associated with tax rates (Andries et al., 2017).

More recently, several studies have examined how income taxes impact commercial bank behavior. For example, using private U.S. commercial banks, Donohoe et al. (2019) find that greater competition from S corporation banks increase the likelihood that rival C corporation banks convert to Subchapter S status and that converting banks increase their interest rates on customer deposits and advertising intensity. Both Schandlbauer (2017) and Milonas (2018) use changes in U.S. state corporate tax rates to address the impact of changing tax rates on financial institutions. Schandlbauer (2017) documents that in response to tax rate increases, banks increase their leverage ratio to benefit from the increased tax shield. Additionally, when faced with higher corporate tax rates, banks who cannot reduce their taxes through increased debt reduce lending. Milonas (2018) suggests that while banks decrease their capital ratio in response to tax rate increases, a symmetric effect exists for tax decreases. The results also hold in cross-country analyses whereby corporate income tax reforms are shown to impact leverage, dividend policies and earnings management of banks (Hemmelgarn and Teichmann, 2014). In a similar vein, Petroni and Shackelford (1995) provide evidence that property-casualty insurers structure their cross-state expansion to mitigate both state tax and regulatory costs.

Prior research also provides evidence that various international tax policies can change multinational bank behavior in an effort to reduce taxes (Gu et al., 2015). Huizinga et al. (2014) find that the international double taxation of foreign income distorts international banking activities by decreasing foreign direct investment. Their study also finds that the impact of the double taxation is passed onto foreign bank customers through higher interest margins. Hepfer et al. (2020) show that taxes were an important incentive for foreign-owned life insurance firms to use shadow insurance pre-TCJA.

In addition to income taxes, governments can tax banks through the use of levies. In the aftermath of the 2007-2008 financial crisis, 14 European countries introduced a bank specific levy on either the banks' secured liabilities, unsecured liabilities, or risk weighted assets.[7] While these levies differ regarding terms and bases, the general purpose was to reduce the riskiness of the banking sector and to ensure that future costs associated with banking crises are internalized by banks so that public funds would not be needed to stabilize the banking sector.[8] To harmonize different national level bank levies, the European Union introduced the Single Resolution Fund, with collections beginning in 2016. Consistent with banks changing behavior in response to changes in taxation, prior research documents that bank specific levies impact individual bank behavior. Devereux et al. (2019) document that while banks reduce their leverage in response to bank levies, they also increase risk. Using a German setting, Buch et al. (2016) find that banks affected by bank levies reduce lending and increase rates. Kogler (2019) extends the results to show that lending and deposit rates increase for countries that adopted a bank levy in the European Union relative to those that did not. While not directly assessing bank profitability, Capelle-Blancard and Havrylchyk (2017) document that banks are only able to shift the burden of the levy to their customers through higher interest and fee margins for borrowers over which they exercise market power.

[7] The 14 European countries are: Austria, Belgium, France, Greece, Hungary, Iceland, Latvia, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden, and the United Kingdom.

[8] A bank levy is a tax on specific elements of the balance sheet. The tax could be on total assets, total regulatory capital, covered deposits, non-insured liabilities or uninsured liabilities. The rationale is to increase the cost of borrowing and thus make banks rely more on equity funding. The bank levy is like a Pigouvian tax: it corrects banks' excessive risk-taking behaviour by making banks pay for the negative externalities associated with bank distress. For example, Germany introduced a progressive bank levy from 0% and 0.06% on total liabilities net of equity and insured deposits. Another tax base is all off-balance sheet derivatives (taxed on their nominal value) with the tax rate of 0.0003%. The levy is capped at 20% of annual net income, but also has a minimum charge of 5% (even if the bank has losses).

2.3 The Effect of Negative Interest Rates on Banks

Prior research has examined the effect of monetary policy on various non-tax behavior. While significant research exists regarding changes in bank behavior and their role as a monetary policy transmission mechanism, the literature is largely based on expansionary or contractionary policy within the confines of positive, albeit at times very low, interest rates. Traditionally, central banks reduce interest rates to promote bank lending. However, in very low interest rate environments, the ability to reduce interest rates to provide monetary stimulus is small (Bernanke, 2020; Borio and Gambacorta, 2017) and could even become contractionary (Brunnermeier and Koby, 2018). Many economists previously believed that Central Banks had a zero lower bound (ZLB) because anything less would cause a widespread conversion of deposits into currency (Swanson, 2018).

Central-bank officials in the U.S. have stated that they prefer to stimulate growth with tools other than negative interest rates, including purchases of long-term securities and explicit guidance about how long they plan to buy assets and keep rates low. The U.S. Federal reserve sees negative rates as a last resort because of potential harmful effects on financial markets and the banking industry (Timiraos, 2020). One of the criticisms of imposing negative interest rates is that it potentially reduces the profitability of banks which could cause higher lending rates and reduce the supply of credit. However, the empirical evidence on bank profitability is somewhat mixed given that the impact on banks of negative interest rate policies varies according to the bank's business model (Bohn et al., 2020). Eggertsson et al. (2017) find that negative interest rates are not passed on through aggregate deposit or lending rates, and that banks are reluctant to reduce deposit rates fearing a loss of their funding base (Heider et al., 2019). Claessens et al. (2018) document that bank profitability is negatively related to the level of lending rates and that while

banks can adjust other aspects of the business to offset low rates, it is difficult for banks to maintain their income if low interest rate environments persist. Consistent with this, Molyneux et al. (2019) find that bank margins and profits fell in negative interest rate adopter countries relative to countries that did not adopt a negative interest rate. In contrast, Lopez et al. (2020) find little overall impact of negative nominal rates on bank profitability because while banks experience losses in interest income, it is almost exactly offset by savings on deposit expenses and gains in non-interest income given that banks can respond to negative interest rates by charging additional fees/commissions or relying less on deposits to maintain margins.

One of the reasons for the conflicting results on bank profitability is that the risk profile of lending may change. For margins to remain unchanged banks may choose to increase risk or reduce lending altogether. This is consistent with Molyneux et al. (2020) who find that, following the introduction of negative interest rates, bank lending was weaker in negative interest rate adoption countries and Bubeck et al. (2019) who find that negative interest rate adoption affects the securities holdings of banks.[9]

2.4 Negative Interest Rates and Taxes

While negative interest rates clearly alter the opportunity cost for banks on holding reserves, whether or not the imposition of negative interest rates impact the tax planning of banks is an open empirical question. Molyneux et al. (2019) document that bank margins and profitability decrease following the adoption of negative interest rates. The results can be explained because bank lending (i.e., volume) decreases (Molyneux et al. 2020) and banks are unable to pass on the increased costs (i.e., margin) to depositors (Heider et al., 2019).

[9] Prior research has documented other effects of negative interest rates. For example, in response to negative interest rates, banks appear to adjust their balance sheets towards riskier asset classes (Basten & Mariathasan, 2018; Demiralp et al., 2017).

Although profitability is reduced, it is unclear how reduced profitability will translate into tax planning. Rego (2003) documents a negative relation between tax planning and pre-tax income in a broad sample that excludes financial firms. While she argues that more profitable firms have greater incentives and resources to engage in tax planning, low profitability may provide a strong incentive in the banking sector to reduce taxes. Low profitability is particularly troublesome for banks because it reduces the banks' ability to build up capital reserves (i.e., retained earnings), which reduces banks' future ability to lend capital. Therefore, current profitability may negatively impact future profitability. With fewer prospects, banks may not be able to raise debt and equity to circumvent the issue. In that sense, the best option may be to raise internally generated funds via tax planning (Edwards et al., 2016).

Prior research has documented in other settings that the introduction of new taxes and/or regulations can sometimes induce a tax substitution effect. Individual banks may alter their business model through reduced risk provisioning (Borio et al., 2017), charging higher fees on other products (Turk, 2016), or increasing risk (Heider et al., 2019). Using value-added tax (VAT) changes, Olbert and Werner (2019) find that firms adjust their output as a response to changes in consumption taxes. Following the introduction of bank levies on bank liabilities, Bremus et al. (2018) find that banks reduce leverage but that the reduction in leverage is less prevalent when banks are faced with higher corporate income tax rates. Taken together, these studies provide evidence of changes in firm and bank behavior to taxes and levies. Based on this prior work, it is possible that banks will increase their tax planning activities in response to the adoption of a negative interest rate regime.

Conversely, banks could try to intentionally overpay taxes in response to the introduction of negative interest rates. Prior work has argued that tax pre-payment does not adhere to the

positive time value of money because it results in an interest-free loan to the government and an opportunity cost of lost interest income (Bobek et al., 2007). However, in a negative interest rate environment, overpayment of taxes could potentially benefit banks as it protects the value of funds from being eroded. The benefit exists if banks do not have better alternatives or the time horizon for negative interest rates is small.

From above, ex-ante, it is not clear how banks will adjust their tax planning in response to negative interest rates. Thus, we make the following null hypothesis:

H1: Negative interest rates are not associated with changes in tax planning behavior in banks.

3. Sample and Research Design

3.1. Sample

Our sample consists of all domestic banks domiciled within the member countries of the Organization for Economic Co-operation and Development (OECD) during the period 2011-2017.[10] We begin our sample period in 2011 to straddle the adoption of negative interest rate regimes that occurred throughout the 2010s. The first country to adopt negative interest rates in our sample is Denmark in 2012. The last country to adopt negative interest rates in our sample is Japan in 2016. We restrict the sample period to a relatively short window straddling the adoption in negative interest rate regimes to alleviate concerns around confounding effects and omitted variable bias (Molyneux et al., 2019). We perform our analysis on banks from OECD countries because the OECD is comprised of a somewhat homogenous group of countries. We do not extend the sample further because the structure of the banking system in the OECD differs from that in

[10] Note, in our primary analysis we exclude U.S. bank observations. This is done because the number of observations from the U.S. would cause our control group to dwarf our treatment group. In additional analyses we reintroduce U.S. banks to the sample and observe broadly similar results.

non-OECD countries (Shehzad et al., 2009). Our sample includes only domestic banks because multinational banks may operate in countries with both negative (i.e., treatment group) and positive interest rates (i.e., control group), which would confound inferences. The restriction to only include domestic banks also avoids the greater heterogeneity that would result from including multinational banks. The inclusion of domestic only banks also alleviates concerns about the effect of country-by-country reporting (CbCR) for multinational banks in the European Union that began in 2014.[11]

In compiling our sample, we select domestic banks at the highest level of consolidation using ownership data retrieved from the Orbis Bank Focus database. This database contains information on both public and private banks. A bank is classified as domestic if it does not have greater than 50% ownership of a foreign subsidiary. A bank is classified as the highest level if it is not a controlled subsidiary or branch of other entities.[12] In the Orbis Bank Focus database, we use the following items for identification: entity type, subsidiaries, shareholders, and ultimate owners. We denote a bank as the highest level in an organization if none of the items indicate that it is a controlled subsidiary or branch. As Orbis collects data from different sources, this approach allows us to reduce the potential sample bias resulting from fragmented information of specific items.[13]

We also use the Orbis Bank Focus database to obtain financial information for the consolidated accounts of the banks in our sample. We drop central banks, multilateral governmental banks, and specialized governmental credit institutions from the sample. We further

[11] Although European Union domestic banks are also subject to CRD IV, CbCR does not provide incremental information about those single country banks.
[12] This definition is consistent with Demirgüç-Kunt & Huizinga (2001):"foreign bank is defined as a bank that is at least 50 percent foreign-owned."
[13] Orbis gathers data from more than 160 separate providers and hundreds of its own sources. See https://www.bvdinfo.com/en-gb/our-products/data/international/orbis

exclude banks that were inactive during the sample period. Finally, we drop all observations with missing data required to compile the test and control variables.

Different countries adopt negative interest rate policies at different times. In our sample, Denmark is the first country to adopt in 2012, and Japan is the last country in 2016. For the timeline of negative policy rate adoption, we rely on Jobst and Lin (2016) (See Appendix A for details). When any of the policy rates—overnight lending, open market operations, or deposit facility—fall below zero, it is considered as the introduction of a negative interest rate. For our difference-in-difference research design, we assign 2015 as the pseudo adoption year for banks in countries without negative interest rate regimes. We select 2015 because the majority of negative policy adoption occurs in that year.[14] As such, using this pseudo date provides a better balance for the control group.[15]

Given our research design, we require at least one observation in the pre-adoption (i.e., pre-negative interest rate regime) period and one observation in the post-adoption (i.e., post-negative interest rate regime) period. Therefore, we drop all observations that do not meet these criteria. We impose the minimum pre-adoption period observation and post-adoption period observation requirement because we are interested in the difference for a specific bank between the two periods. After our screening procedure, the final sample consists of 404 unique banks and 2,227 bank-year observations.

[14] In our primary analyses we exclude U.S. banks for several reasons i) our treatment banks are all in Europe and Asia, ii) including U.S. banks in the main analysis overwhelms the sample (there are 4 times as many U.S. observations than all other OECD country observations combined). In supplemental analysis, we confirm inferences hold when including U.S. banks.

[15] In untabulated tests, we assign 2014 as the pseudo adoption year and repeat all the relevant tests, inferences remain unchanged.

3.2. Primary Analysis, Difference-in-difference Test

In our primary analyses, we use a difference-in-difference research design. The difference-in-difference design lends itself to this setting since there are staggered adoption dates and, from the banks' point of view, negative interest rates are generally regarded as an exogenous and unexpected shock (Campos 2019; Schelling and Towbin 2018).

We first exploit the staggered introduction of negative interest rates in different countries to compare the change in the tax planning of banks operating in countries with negative interest rate policies (i.e., treatment group) with the change in the tax planning of banks in other OECD countries (i.e., control group) using the following model.

$$ETR_{ijt} = \beta_0 + \beta_1 Treat_{ij} * Post_t + \delta X_{ijt} + \mu_i + \theta_t + \varepsilon_{ijt} \quad (1)$$

The dependent variable, *GAAP ETR*, is our proxy for tax planning.[16] This variable is measured as the tax expense over the pre-tax income of bank i at time t. We reset extreme values of *GAAP ETR*, or those below 0 or above 1, to 0 and 1 respectively. $Treat_{ij}$ is an indicator variable that is set equal to one if bank i is in country j where a negative interest rate is adopted, and zero otherwise.[17] $Post_t$ is an indicator variable that is set equal to one for all years, including the introduction year, when a negative interest rate is adopted in the firms' operating country, and zero otherwise. The coefficient of interest, β_1, represents the relative change in tax planning, proxied by *GAAP ETR*, between the banks that are subject to, and the banks that are not subject to, a negative interest rate regime.

[16] Alternative measures of tax burden, such as current tax expense and cash taxes paid are not available in a machine-readable format for our sample of banks.

[17] We use an indicator variable, as opposed to a continuous measure of central bank interest rates, for several reasons. First, as discussed in section 2, our hypothesized relation is based on the introduction of a negative interest rate regime (i.e., a cost outflow from banks to central banks). We do not expect our hypothesized relation to be linear in central bank rates, a fact we exploit in a falsification test in section 4. Second, a binary treatment variable allows for greater ease of interpretation of the interaction term in our difference-in-difference research design.

In addition to the primary variables of interest, we also include control variables for other time-varying bank characteristics that may influence bank tax planning ($X_{i,t}$). At the bank level, we follow prior literature, namely Overesch and Wolff (2021), and include control measures of bank size (log of total assets), profitability (*ROAE*), and equity ratio (the ratio of equity to total assets). The first two control variables relate to the potential (i.e., size) and incentive (i.e., profitability) for tax planning while the equity ratio controls for capital structure. Liquidity risk is controlled for using the ratio of liquid assets over total assets and cost efficiency is controlled for using the cost to income ratio (i.e., the ratio of operating expenses on net operating income). In some specifications, additional controls for banks' business models are used, including *Non-interest Income Ratio*, *Fees & Commissions Ratio*, *Interest Income Ratio*, *Interest Expenses Ratio* and *Net Interest Margin*, which all capture components of bank profitability (Altavilla et al., 2018). All bank-level variables are winsorized at the 1% and 99% levels to reduce the effect of outliers on our analyses.

At the country level, our model includes control variables for the statutory tax rate (*STR*), *GDP Growth*, and *Inflation* (measured using the consumer price index). *GDP Growth* is included as it affects bank profitability through supply and demand of funds (Molyneux et al., 2019). *Inflation* is included as a control given that inflation impacts the operating costs of banks (Albertazzi and Gambacorta, 2010) and investors require a nominal return (Demirgüç-Kunt and Huizinga, 2001). Country-specific controls are taken from KPMG's tax handbooks and World Bank databases. Detailed variable definitions are presented in Appendix C.

In addition to the country and bank characteristics discussed above, our regression models also include indicator variables to capture bank fixed effects (μ_i) to absorb unobservable time-invariant bank characteristics, and year fixed effects (θ_t), in order to control for common time

effects. By using a research design with extensive fixed effects, we exploit within-firm variation to identify the effect of a negative interest rate regime on tax planning.

4. Primary Empirical Analyses

4.1 Descriptive Statistics

Table 1 presents the sample composition. As presented in Panel A, 2011 and 2012 have relatively fewer observations but the number of observations per year stabilizes to be between 340-400 banks beginning in 2013. Regarding the sample composition by country, Japan ranks first (26.76%), followed by France (9.56%) and Norway (6.06%). Together, banks in the European Union comprise 38.12% of the sample. For the control group, Canada has the highest number of observations (15.27%), followed by the United Kingdom (6.29%) and Australia (5.43%). Regarding bank specification, commercial banks and cooperative banks comprise most of the sample at 33.88% and 21.96% respectively.

<insert Table 1 here>

Table 2 reports the descriptive statistics for the test and control variables. Panel A displays the descriptive statistics of the pooled sample while Panel B presents the descriptive statistics of the treatment and control group before and after the introduction of the negative interest rate regime. The mean (median) *GAAP ETR* for the pooled sample is 28.00% (26.81%). For banks in the treatment group, the mean *GAAP ETR* is lower in the post-negative interest rate period (27.81%) than in the pre-negative interest rate period (33.24%). At the same time, the mean *GAAP ETR* for banks in the control group stays nearly the same at around 23%.

Panel C separately presents the descriptive statistics for the treatment and control groups across key variables. Banks in the treatment group are, on average, larger, less profitable, less liquid, and have lower equity ratios. We note some changes in bank characteristics after the

introduction of negative interest rate policies in Panel B. Banks in the treatment group experience an increase in *ROAE* after the introduction of negative interest rates with the mean (median) increasing from 5.85% (4.90%) to 6.44% (5.59%), while banks in the control group exhibit a slight decrease from 9.22% (7.7%) to 8.91% (7.34%). One potential explanation for this is that the introduction of negative interest rates cause a change in the business model of treated banks. This is consistent with the findings of Heider et al. (2019). While we do not observe a clear pattern of a change in the *Net Interest Margin*, we note an increasing trend in non-interest-orientated income. More specifically, the mean (median) of *Net Interest Margin* for the treatment group increased (decreased) from 1.63% (1.51%) to 1.73% (1.49%) after the introduction of negative interest rate regimes; while the mean (median) for the control group decreased (increased) from 2.59% (1.89%) to 2.53% (1.92%).

In regard to the other components of profitability, while the measure of *Non-interest Income Ratio* remained relatively constant for control banks, we note a substantial increase for treated banks as the mean (median) increased from 32.57% (28.73%) to 41.23% (40.84%). We also observe an increase in the *Fees & Commissions Ratio* for treated banks. These trends are consistent with Lopez et al. (2020) and Basten and Mariathasan (2018) and indicate that banks respond to negative interest rates by adjusting other aspects of their business. Statistics also reveal an average increase in the *Equity Ratio* for treated banks, with the mean (median) increasing from 9.11% (6.12%) to 11.61% (8.78%), but not for the control group which stays at approximately the same level.

Panel D presents Pearson correlations among the primary variables. Univariate evidence documents that *GAAP ETR* is positively related to *Size*, *Cost-to-income Ratio* and *STR*, and negatively related to *ROAE*, *Equity Ratio*, *Liquidity Ratio*, *GDP Growth* and *Inflation*.

<insert Table 2 here>

4.2 Primary Empirical Results, Staggered Difference-in-difference

We start the multivariate analysis by running baseline regressions using a staggered difference-in-difference specification. Table 3 presents the results using the full sample. We are primarily interested in the coefficient on *Treat*Post*, which represents the average difference in the *change* of *GAAP ETR*s between banks subject to and not subject to the implementation of a negative interest rate regime. A negative and statistically significant coefficient on *Treat*Post* suggests that, relative to banks in the control group, treated banks increase tax planning after the adoption of negative interest rates.

In Table 3 columns (1) and (2), banks' *Size* and *Profitability* are included in the regression model to control for the possibilities and pressure of tax planning, and the equity ratio is included to control for capital structure. We also include the ratio of liquid assets to control for liquidity risk, and the cost to income ratio to control for cost efficiency. At the country level, statutory tax rate (*STR*), *GDP Growth*, and *Inflation* are included as control variables. Column (3) and (4) add additional controls regarding banks' business models, including *Non-interest Income Ratio, Fees & Commissions Ratio, Interest Income Ratio, Interest Expenses Ratio* and *Net Interest Margin*. Due to data availability, the addition of these controls results in a reduced sample. To address concerns about the impact of the denominator in measuring tax planning for the dependent variable, Column (2) and (4) additionally employ the variable *One over Pre-tax Profit* (Edwards et al., 2020). Among these variables, *Size* shows a positive correlation with *ETR*, compared to a negative correlation with *ROAE* and *Cost-to-income*. Our interpretation is that smaller banks, more profitable banks, and less cost-eSfficient domestic banks have a greater incentive to engage in tax planning.

The coefficient of interest, *Treat*Post* is negative and significant at the 5% level in columns (1) and (2) and at the 10% level in columns (3) and (4). Our primary analysis provides evidence consistent with the introduction of a negative interest rate being associated with an approximate 2.3 to 2.6 percentage point decrease in *GAAP ETR*. For the economic significance of this result, we provide an example within the context of the Eurozone. According to the FinTech company, Deposit Solutions, the amount that banks paid for negative interest rates in the Eurozone was equal to 4% of pre-tax profit in 2018.[18] Thus, the magnitude of *GAAP ETR* decreases in response to negative interest rate policies is economically meaningful.

<insert Table 3 here>

4.3 Robustness Tests and Additional Analyses

4.3.1 Alternative Control Samples

One possible concern with our primary analysis is that our primary results could be driven by some of our sample selection choices. This subsection presents evidence that both our results and inferences are robust to a number of alternative sample selection choices.

First, as noted in Section 3.1, our primary analysis excludes observations of U.S. banks. In our first robustness test we include U.S. banks in the sample and repeat the main analysis. Table 4 columns (1) and (2) report results using this expanded sample. When including U.S. banks, the coefficients on *Treat*Post* are even more negative and significant as compared to our baseline specification. With this broader control sample, we observe a 4 percentage point decrease in *GAAP*

[18] The 4% is calculated, using data from the European Central Bank, as total deposit charges for Eurozone banks divided by pre-tax profits before excess liquidity charges. The following items were used for this calculation: excess liquidity volumes, deposit rates, interest on excess liquidity, and banking profitability. Deposit balances with central banks that are not charged to banks were not taken into account. https://www.deposit-solutions.com/pressemitteilung/

ETR for treated banks relative to control banks, with coefficients that are statistically significant at the 1% level.

We next repeat the main analysis but exclude Japanese banks because Japan underwent a tax reform in 2016 (EY, 2016; PwC, 2016) which could confound the test. Results are presented in columns (3) and (4). The results are robust with the magnitude and significance of the coefficients consistent with those reported in the main analysis in Table 3. These results also provide some comfort that our results are not driven by a specific country given that Japanese banks represent the largest percentage of observations in our sample (26.76%).

Next, we limit the sample to the global ultimate owners and exclude banks classified as an "independent company" or "single location". As reported in columns (5) and (6), the coefficients on *Treat*Post* remain negative and statistically significant with this specification. For global ultimate owners, treated banks relative to control banks, are associated with a roughly 3 percentage point decrease in *GAAP ETR* following the introduction of negative interest rates. This observed effect is slightly larger than the effect observed in the full sample (Table 3).

The date that a central bank implements negative interest rates might not coincide perfectly with a bank's fiscal year-end. Banks have different closing dates for their financial year-ends such that some year-ends are before the implementation date and some are after. Additionally, banks may not have the time or ability to adjust their tax planning immediately. As such, we would expect the results to be stronger if we allow for the treated banks to have more time to react to the negative interest rate regime. Therefore, we exclude the implementation year for each country from the sample and repeat our primary analysis. Results using this sample are presented in columns (7) and (8). In line with our prediction, the coefficients on *Treat*Post* stay significant at the 1% level and become more negative than in the baseline specification presented in Table 3.

Although bank fixed effects absorb the influence of time-invariant bank characteristics, it is possible that some bank-specific tax planning items change over time. In column (9), we include additional bank-level control variables as a further robustness test. Previous literature suggests that loan loss provisions can be involved in tax planning (Scholes et al., 1990), and off-balance sheet items, like contingent claims, have tax effects (Reagle, 2006). Therefore, we add *Credit Risk* (the ratio of loan loss provisions on total assets) and *Off-balance Sheet Ratio* (the ratio of off-balance sheet items on total assets) in the regression. We set *Credit Risk* to zero if data is missing or negative, and set *Off-balance Sheet Ratio* to zero if missing.[19] With the additional control variables, the coefficient remains negative and significant (at the 1% level) with a comparable magnitude to our primary results in Table 3.

<insert Table 4 here>

4.3.2 Event-based Difference-in-difference

To address the potential drawbacks of a staggered difference-in-difference design, as an additional robustness test, we align the event time of negative interest rate regime adoptions for our sample. This has several advantages. First, this alignment enables us to assess the parallel trend assumption before treatment. Second, staggered difference-in-difference tests may have a biased average effect because of the maturation differences between both groups over time. Our event-based difference-in-difference design follows Cengiz et al. (2019) and focuses on the short-term effect around the adoption of negative interest rate policies. By stacking and aligning different treatment events in event-time, the test becomes similar to a setting with a contemporaneous treatment.

[19] We do not include these controls in the main specification as this information is missing for a substantial number of our sample observations, reducing the sample size.

Figure 1 plots the mean of the difference between the statutory tax rate and the *GAAP ETR* for the treatment and control groups over event-time. Banks in the treatment and control groups appear to satisfy the parallel trends assumption before the adoption. On average, the difference between the statutory tax rate and *GAAP ETR* in the treatment group is smaller than the difference in the control group in the pre-negative interest rate period. However, the difference between the rates is higher for treatment firms in the year after the implementation of negative interest rates, before falling to a similar level two years later. As explained earlier, the effect in the implementation year may be confounded. In this figure, we observe that the biggest effect occurs one year after the adoption.

We employ our next battery of robustness tests using an event-based difference-in-difference design with an aligned event period. Our sample period starts with three years before the introduction of a negative interest rate regime and ends with three years after the introduction of the negative interest rate regime (i.e., 7 years in total).[20] For banks in countries without a negative interest rate regime, we assign 2015 as the pseudo policy year.[21] Table 5 columns (1) and (2) present the results of our aligned difference-in-difference test. Importantly, our coefficient of interest, *Treat*Post* is negative and significant at the 10% level. The magnitude (2.1 percentage points to 2.2 percentage points) is similar, although slightly smaller than, our primary findings (2.3 percentage points to 2.6 percentage points).

Next, to address potential concerns that banks in the treatment group and the control group might not be comparable, we re-estimate our difference-in-difference model using matched pairs of treatment and control banks. To do this analysis, we use a probit model to estimate a propensity

[20] Note that for Japanese banks, we do not have observations in the third year after the adoption due to data availability (i.e., the event occurred later in Japan than in other treatment countries).
[21] As previously stated, in robustness tests, inferences remain unchanged when using 2014 as an alternative pseudo adoption year.

score of treatment assignment based on size, profitability (*ROAE*), equity ratio, and liquidity of the banks in the year before the negative interest rate regime adoption. To match the treated banks with suitable banks in the control group, we perform 1:1 nearest neighbor matching without replacement. Intuitively, we create matched pairs by identifying a bank in the control group that is similar with respect to the above-mentioned characteristics to a bank in the treatment group. Given that we have more banks in the treatment group than in the control group in the main sample, we allow for U.S. banks to serve as control banks in the matching pairs. The results using this propensity score matched sample are presented in Table 5 columns (3) and (4). Consistent with results obtained using our primary sample, we report a negative and significant coefficient on the interaction term *Treat*Post.* The magnitude of the effect is similar to the magnitude observed in our main analyses.

<insert Table 5 here>

4.3.3 Falsification test

To further strengthen inferences from our findings, we next perform a falsification test to mitigate concerns that our findings may be an artifact of our research design. If our tests represent casual evidence of the effect of a negative interest rate, we should not find significant results when using an arbitrary cut-off rate. We conduct this falsification test by setting the cut-off rate at 0.05% instead of a zero policy interest rate. This cut-off point is close to the zero threshold we study, which should occur under broadly similar (although likely less severe) economic conditions. Selection of this cut-off rate allows us to implement the same difference-in-difference research design without any reversals of the pseudo treatment.[22]

[22] We set the falsification cut-off rate at 0.05% because otherwise one of our sample countries, the Czech Republic, goes below the cut-off point in 2012 and reverses in 2016..

The results of this test are reported in Table 6. In this falsification analysis, the coefficient on *Treat*Post* is not significantly different than zero using the incorrect cut-off rate. This is consistent with expectations and provides added evidence that allow us to infer that the negative interest rate adoption affects banks' corporate tax behavior.

<insert Table 6 here>

5. Supplemental Analyses

5.1. Cross-sectional variation: Low vs. High Distance to Insolvency Banks

It is possible that some banks may be more acutely impacted by the imposition of negative interest rate policies than others. We examine this possibility using a number of different bank characteristics where variation would be predictable. These tests add context to our primary findings and provide additional confirmatory evidence of our results using a further source of identification.

We first investigate the impact of bank financial constraints. Prior research has documented that financially constrained firms are more likely to employ alternative funding sources like tax savings (Edwards et al., 2016). Following the adoption of negative interest rate policies, we expect that more financially constrained banks will increase their tax planning more than less-constrained banks in order to generate cash flow.

To capture bank financial constraints, we use a measure of bank distance to insolvency. Following Schepens (2016), the distance to insolvency score is calculated as the sum of return on assets and the equity ratio, over the standard deviation of the returns in pre-negative interest rate years.[23] A high distance to insolvency score indicates that there is more room for returns to fall

[23] Some prior literature label the measure as the Z-score, see Houston et al. (2010), Laeven & Levine (2009), and Schepens (2016). We use the term "Distance to Insolvency" to avoid confusion with the Altman (1968) Z-score, a commonly used default risk measure outside of financial institutions.

before equity becomes negative and is thus an indication for stability. We split the sample into two subgroups based on the median distance to insolvency score per country in the year before the introduction of a negative interest rate regime. We split the sample by country because countries adopt the regime at different times and the rates implemented can vary; thereby indicating that banks in different countries are affected differently. Splitting the sample by country also mitigates concerns that the results are driven by certain countries or specific country characteristics. We split bank observations in the control group together with the treatment group, and use the values of 2014 reserves as the partition.[24]

Table 7 columns (1) and (2) show that the coefficient capturing the effect of a negative interest rate is only significant when banks have a low distance to insolvency. Columns (3) and (4) further show that only the low distance to insolvency group of banks display negative and significant coefficients.[25]

Overall, in line with our expectations, the effect of a negative interest rate on *GAAP ETR* is more pronounced in banks that are closer to insolvency.

<insert Table 7 here>

5.2. Cross-sectional variation: Low vs. High Reserve Banks

We further investigate whether the effect of a negative interest rate on tax planning is different conditional on the level of bank reserves. On one hand, less capitalized banks with lower reserves are more likely to face financial difficulties. Conversely, banks holding high excessive reserves face a higher *de-facto* tax with the introduction of negative interest rates. One would

[24] For this analysis, we exclude observations from countries with only a single back in the sample. This restriction removes Israel, Iceland, Latvia, Netherlands, and Poland.

[25] Note, the difference in the coefficients between the two subgroups in column (1) and (3) is statistically significant at traditional levels (Prob > F = 0.0386). The difference in the coefficients between the two groups in column (3) and (4) is not significant at traditional levels (Prob > F = 0.6005).

expect that banks may seek to offset the additional payments to the government by reducing their income tax payments (i.e., a substitution effect).

We explore the cross-sectional variation in banks that hold different levels of reserves as measured by cash at the central bank scaled by total assets.[26] Again, we split the sample into two subgroups based on the median value of banks' *Cash at Central Bank* per country in the year before the introduction of the negative rate regime.[27] Table 8 presents the results with the treatment group compared to the partitioned control group.

Our results from this test are consistent with our primary effect being concentrated in the subsample of banks that have low reserves. In this subsample, the coefficients on *Treat*Post* are negative and significant at the 1% level and are stronger than our baseline results in Table 3. We do not find evidence of a negative interest rate regime's influence in the subgroup of banks with high reserves.[28] Our interpretation of this result is that banks with lower reserves at central banks are more likely to face financial difficulties, and thus are more likely to increase tax planning to offset the negative interest charges faced after the introduction of a negative interest rateregime.

<insert Table 8 here>

5.3. Cross-sectional variation: Low vs. High Tax Enforcement

The observed tax substitution effect should also vary based on the level of tax enforcement on corporate income tax. Banks in low enforcement environments should be better able to increase their income tax avoidance in response to the implementation of a negative interest rate regime.

[26] We do not use Tier 1 capital ratio because it is likely to be driven by risk-weighted assets, the denominator, not only capital level. See Gropp et al. (2019) and Mariathasan & Merrouche (2014) . Also, Tier 1 capital includes deferred tax assets to some extent.

[27] Again, we exclude countries with only one bank in the sample for this split analysis. This restriction removes Estonia, Israel, Iceland, Latvia, Poland and Slovakia.

[28] Note, the differences in the coefficients between the two subgroups are not statistically significant at traditional levels (Prob > F = 0.3090, Prob > F =0.5519 respectively).

Accordingly, we investigate the cross-sectional variation in our hypothesized relation with respect to a country's enforcement level.

We follow De Simone et al. (2019) and measure *Enforcement* using tax enforcement spending in a country as a percentage of GDP. This measure captures the amount of financial resources allocated to income tax enforcement efforts in the country. A non-trivial portion of enforcement is allocated to corporate taxpayers.

We partition the sample based on the median value of *Enforcement* in 2011, the first year of our sample period.[29] Table 9 presents the results of the regressions for the two subsamples with low and high levels of tax enforcement respectively. Our results are consistent with the increase in tax avoidance following the implementation of negative interest rate regimes being concentrated in countries where the level of tax enforcement is low. In this subsample, the coefficients on *Treat*Post* are negative and significant at the 1% level. Conversely, we do not observe a significant coefficient on *Treat*Post* when the level of tax enforcement is high.[30] We interpret these results as consistent with the notion that the tax substitution effect is stronger when tax enforcement is low.

<insert Table 9 here>

6. Conclusion

Central banks introduce negative interest rates to encourage lending and to stimulate the economy. By imposing a charge on excess bank reserves, negative interest rates serve as a *de-facto*

[29] Again, we exclude countries with only one bank in the sample for this split analysis. This restriction removes Estonia, Israel, Iceland, Latvia, Poland and Slovakia.

[30] Note, the differences in the coefficients between the two subgroups are not statistically significant at traditional levels (Prob > F = 0.1969, Prob > F =0.3088 respectively).

tax levied on excess liquidity. In this paper, we examine whether this new "tax" (i.e., negative interest rates) affects corporate tax planning.

The trend towards using negative interest rates as a monetary policy instrument is becoming increasingly more prevalent. Using a difference-in-difference research design with bank- and time-fixed effects, we find that banks increase their tax planning in response to negative interest rates. After the implementation of a negative rate regime, affected banks have a 2.3 to 2.6 percentage point decrease in their GAAP ETR relative to unaffected banks. Further tests reveal that this effect is stronger for financially constrained banks (i.e., banks closer to insolvency and banks with lower reserves) and banks in low enforcement environments.

By showing the effect of negative interest rates on corporate tax behaviors, we contribute to the debate on the consequences of negative interest rates. Additionally, we add to the literature on banks' tax planning behaviors by showing that banks adjust their behaviour in response to changes in monetary policy.

The findings of our study are potentially of interest to policymakers. We provide evidence that could be relevant when central banks are considering the implementation of negative interest rates. Given the current environment of persistently low interest rates, many countries may consider the adoption of this monetary tool. By showing the spillover effect of this monetary policy on corporate taxes, we add to the on-going discussion on the consequences of negative interest rates.

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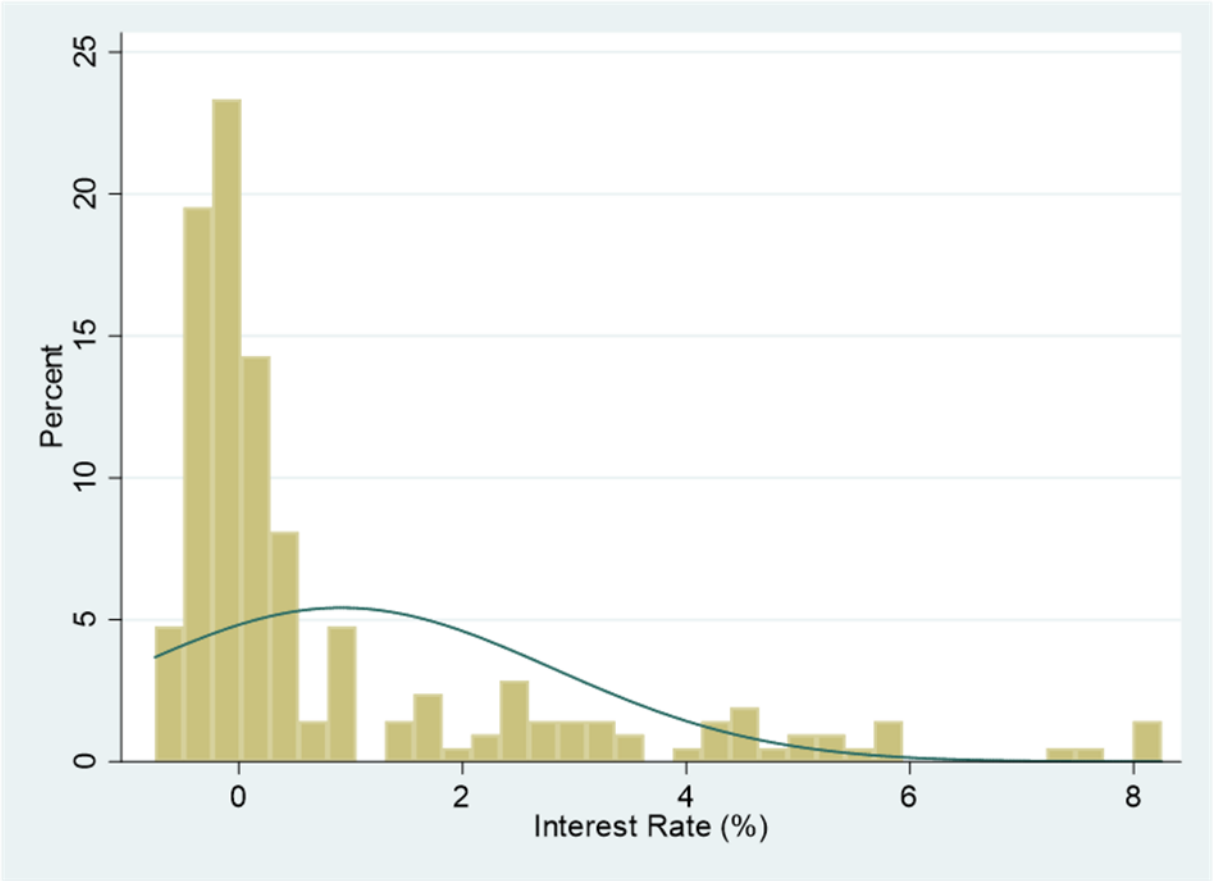
Appendix A: Timeline of Central Bank Negative Interest Rates

Country	Time of introduction	Instrument	Objective
Demark	July. 6, 2012-April. 24, 2014 and Sept. 05, 2014	One week certificate of deposit rate	Countering safe-haven inflows and exchange rate pressures (continued FX interventions)
Euro Area	June. 11, 2014	ECB's deposit facility rate	Price stability and anchoring inflation expectations (together with asset purchase program)
Japan	Feb. 16, 2016	policy rate balance, the residual reserve deposit	Price stability and anchoring inflation expectations (together with asset purchase program)
Norway	Sept. 24, 2015	Reserve rate	Price stability
Sweden	Feb. 18, 2015	One week repo rate	Price stability and anchoring inflation expectations (together with asset purchase program)
Switzerland	Jan. 15, 2015	Overnight sight deposit rate	Reducing appreciation and deflationary pressures

Source: Jobst and Lin (2016)

Note: Negative interest rates are identified using Central Bank policy interst rate. Specifically, we use the overnight deposit facility rate from the European Central Bank; the cash rate target from the Reserve Bank of Australia; the target for the overnight rate from the Bank of Canada; the interest rate for the permanent deposit facility from the Central Bank of Chile (Banco Central de Chile); the two-week repo rate from the Czech National Bank; the one week certificate of deposit rate from the Danmarks Nationalbank (Nationalbanken); the simple average of the current account rate, and the maximum rate on 28-day certificates of deposit before 2014 and the seven-day term deposit rate after May 21, 2014 from the Central Bank of Iceland; the target rate of the central bank from the Bank of Israel; the complementary deposit facility (policy rate balance after February 16, 2016) from the Bank of Japan; the interest rate target for the overnight rate from the Bank of Mexico; the official cash rate from the Reserve Bank of New Zealand; the reserve rate from the Norges Bank; the deposit rate from the National Bank of Poland; the deposit rate from the Bank of Korea; the one week repo rate from the Sveriges Riksbank; the overnight sight deposit rate from the Swiss National Bank; the one week repo rate from the Central Bank of the Republic of Turkey; the official bank rate IUDBEDR (base rate) from the Bank of England.

Appendix B Distribution of Central Bank Policy Rates



This figure present the frequency of policy interest by county-year from Central Banks in our sample.

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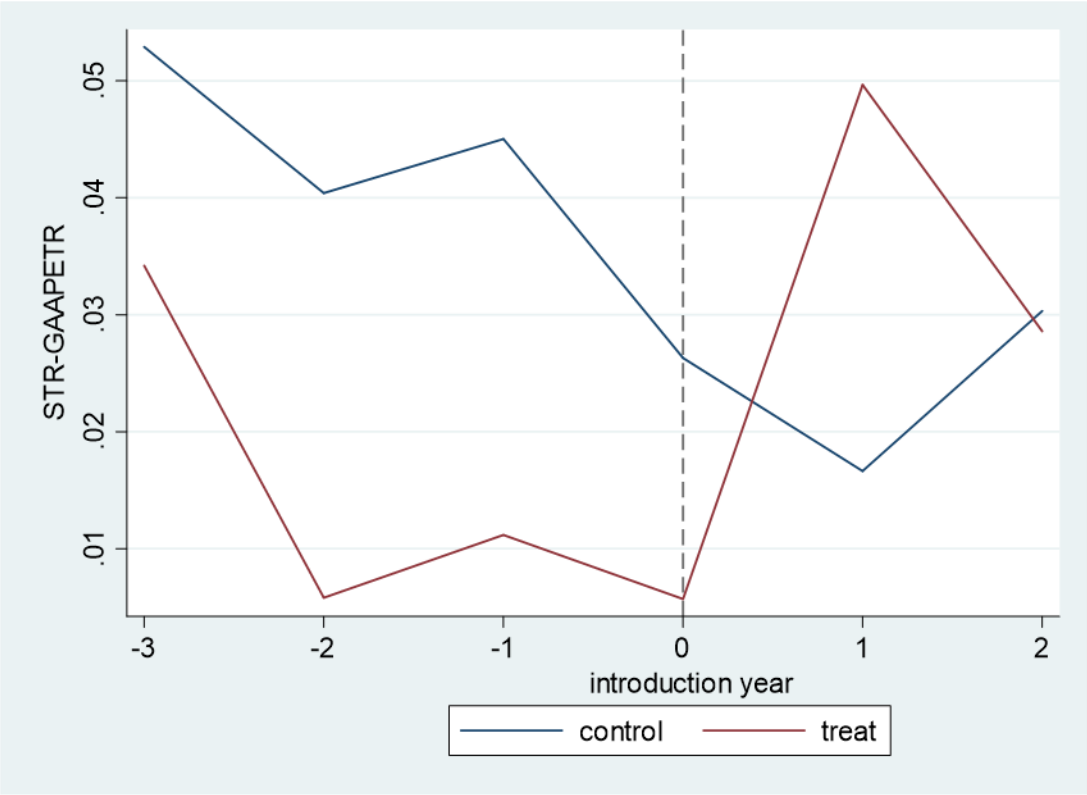
Appendix C Variable Definitions and Construction

Variable	Definitions	Source
Firm level		
ETR	Tax expense scaled by pre-tax income	Bureau van Dijk Bank Focus
Treat	An indicator variable that equals one if the bank is in the country where a negative interest rate is adopted, and zero otherwise.	Appendix A
Post	A indicator that equal to one for years during and after a negative interest rate is adopted, and zero otherwise.	Appendix A
Size	The natural logarithm of bank total assets	Bureau van Dijk Bank Focus
ROAE	Return on average equity	Bureau van Dijk Bank Focus
Equity Ratio	The ratio of bank equity on total assets	Bureau van Dijk Bank Focus
Liquidity Ratio	The ratio of bank liquid assets on total assets	Bureau van Dijk Bank Focus
Cost-to-income Ratio	The ratio of operating expenses on net operating income.	Bureau van Dijk Bank Focus
Non-interest Income Ratio	The ratio of non-interest income on operating revenues	Bureau van Dijk Bank Focus
Fees & Commissions Ratio	The ratio of fees and commissions income to total assets	Bureau van Dijk Bank Focus
Interest Income Ratio	The ratio of interest income on total assets	Bureau van Dijk Bank Focus
Interest Expenses Ratio	The ratio of interest expenses on total assets	Bureau van Dijk Bank Focus
Net Interest Margin	The difference between interest earning assets and interest bearing liabilities divided by the amount of interest earning assets	Bureau van Dijk Bank Focus
One over Pretax Profit	One over pre-tax income	Bureau van Dijk Bank Focus
Credit Risk Ratio	The ratio of loan loss provisions on total assets. It is set to 0 for negative and missing values.	Bureau van Dijk Bank Focus
Off-balance Sheet Ratio	The ratio of off-balance sheet items on total assets. It is set to 0 for missing values.	Bureau van Dijk Bank Focus

Cash at Central Bank	Cash and balances at central bank scaled by total assets	Bureau van Dijk Bank Focus
Distance to Insolvency	The sum of return on assets and the equity ratio over the standard deviation of the returns	Bureau van Dijk Bank Focus
Country level		
STR	The average statutory corporate income tax rate in the country	KPMG
GDP Growth	The annual percentage growth rate of GDP	World Bank
Inflation	The yearly consumer price index in percentage	World Bank
Enforcement	Total spending on tax enforcement as a percentage of country-year GDP in 2011	OECD Tax Administration Comparative Information Series

Figure 1 Difference between the *STR* and the GAAP ETR over Time



This figure displays the average difference between statutory tax rate and GAAP ETR for the treatment group and control group over time. We do not display the third year after the adoption because Japan do not have data for that year. As Japanese banks make up a significant proportion of our treated sample, the plots are not representative for that year.

Table 1 Sample Descriptive
Panel A: Sample Distribution by Year

year	*Treat***Post*=0	*Treat***Post*=1	Total Observations	Percent
2011	180	0	180	8.08
2012	200	5	205	9.21
2013	337	4	346	15.31
2014	272	117	398	17.47
2015	237	149	395	17.33
2016	142	233	384	16.84
2017	135	216	359	15.76
Total	1,503	724	2,227	100

Panel B: Sample Distribution by Country

Country Name	Observations	Percent	Negative Interest Rate Regime
AUSTRALIA	121	5.43	
AUSTRIA	23	1.03	yes
BELGIUM	26	1.17	yes
CANADA	340	15.27	
CHILE	19	0.85	
CZECH REPUBLIC	9	0.4	
DENMARK	32	1.44	yes
ESTONIA	5	0.22	yes
FINLAND	50	2.25	yes
FRANCE	213	9.56	yes
GERMANY	117	5.25	yes
ICELAND	7	0.31	
ISRAEL	5	0.22	
ITALY	78	3.5	yes
JAPAN	596	26.76	yes
LATVIA	6	0.27	yes
LUXEMBOURG	11	0.49	yes
MEXICO	52	2.33	
NETHERLANDS	15	0.67	yes
NEW ZEALAND	8	0.36	
NORWAY	135	6.06	yes
POLAND	10	0.45	
PORTUGAL	10	0.45	yes
REPUBLIC OF KOREA	47	2.11	
SLOVAKIA	5	0.22	yes
SPAIN	59	2.65	yes
SWEDEN	40	1.8	yes
SWITZERLAND	21	0.94	yes
TURKEY	27	1.21	
UNITED KINGDOM	140	6.29	
Total	2,227	100	

Panel C: Sample Distribution by Bank Specialization

Specialization	Freq.	Percent
Bank holdings & Holding companies	196	8.8
Commercial banks	754	33.86
Cooperative banks	489	21.96
Finance companies	97	4.36
Investment & Trust corporations	125	5.61
Investment banks	47	2.11
Other non banking credit institutions	6	0.27
Private banking / Asset management companies	28	1.26
Real Estate & Mortgage banks	219	9.83
Savings banks	238	10.69
Securities firms	28	1.26
Total	2,227	100

Table 2: Descriptive Statistics
Panel A: Pooled Sample

	Count	Mean	SD	Min	Max	p25	p50	p75
GAAP ETR	2,227	28.00%	15.00%	0.00%	100.00%	21.00%	27.00%	34.00%
Size	2,227	15.93	2.91	8.44	24.48	14.27	15.83	17.06
ROAE	2,227	7.17%	5.50%	0.20%	32.79%	3.87%	5.66%	8.89%
Equity Ratio	2,227	13.30%	19.01%	2.94%	99.21%	5.49%	7.47%	11.77%
Liquidity Ratio	2,227	18.62%	21.96%	0.47%	99.38%	5.16%	10.05%	21.36%
Cost-to-income Ratio	2,227	65.87%	17.99%	3.07%	98.75%	55.98%	68.53%	78.69%
Non-interest Income Ratio	2,142	34.48%	28.03%	-181.13%	147.58%	18.09%	31.39%	47.16%
Fees & Commissions Ratio	2,142	2.08%	7.37%	0.00%	61.59%	0.23%	0.42%	1.10%
Interest Income Ratio	2,142	2.89%	2.29%	0.36%	15.96%	1.38%	2.56%	3.55%
Interest Expenses Ratio	2,142	1.14%	1.08%	0.00%	4.88%	0.13%	1.00%	1.76%
Net Interest Margin	2,142	1.98%	1.86%	0.12%	14.21%	1.24%	1.57%	2.06%
One over Pretax Profit	2,227	3.20E-04	1.55E-03	0.00E+00	1.33E-02	1.00E-05	2.00E-05	8.00E-05
STR	2,227	29.13%	5.40%	15.00%	40.69%	26.00%	29.79%	33.33%
GDP Growth	2,227	1.69	1.23	-2.98	8.49	0.96	1.79	2.36
Inflation	2,227	1.32	1.35	-1.14	11.14	0.37	1.11	1.95

Notes: Panel A shows descriptive statistics of the pooled sample. All variables are as defined in Appendix C.

Panel B: Treatment v.s. Control Groups, Pre. v.s. Post-introduction of Negative Interest Rates (NIR)

	Treatment Group pre-NIR							
	Count	Mean	SD	Min	Max	p25	p50	p75
GAAP ETR	718	33.24%	16.66%	0.00%	100.00%	23.09%	34.93%	41.87%
Size	718	16.79	2.64	8.44	24.48	15.39	16.62	17.51
ROAE	718	5.85%	4.32%	0.20%	32.79%	3.47%	4.90%	6.60%
Equity Ratio	718	9.11%	11.21%	2.94%	98.47%	4.72%	6.12%	9.04%
Liquidity Ratio	718	15.63%	17.51%	0.47%	97.20%	4.84%	8.25%	17.71%
Cost-to-income Ratio	718	69.07%	14.16%	3.07%	98.75%	60.54%	71.06%	78.99%
Non-interest Income Ratio	706	32.57%	21.51%	-14.57%	102.71%	19.14%	28.73%	42.98%
Fees & Commissions Ratio	706	1.28%	4.40%	0.00%	61.59%	0.24%	0.32%	0.80%
Interest Income Ratio	706	2.20%	1.34%	0.36%	10.40%	1.29%	1.59%	3.18%
Interest Expenses Ratio	706	0.76%	0.88%	0.04%	4.59%	0.10%	0.17%	1.48%
Net Interest Margin	706	1.63%	0.86%	0.12%	8.12%	1.27%	1.51%	1.77%
One over Pretax Profit	718	9.55E-05	5.02E-04	7.44E-09	8.70E-03	5.05E-06	1.35E-05	4.27E-05
STR	718	33.41%	5.08%	15.00%	40.69%	29.55%	33.86%	38.01%
GDP Growth	718	0.89	1.09	-2.98	4.13	0.37	1.03	1.50
Inflation	718	1.22	1.10	-0.69	3.53	0.35	0.86	2.11

Treatment Group post-NIR								
	Count	Mean	SD	Min	Max	p25	p50	p75
GAAP ETR	724	27.81%	13.94%	0.00%	100.00%	20.18%	27.99%	33.70%
Size	724	16.26	2.67	8.44	24.48	14.63	16.09	17.13
ROAE	724	6.44%	4.59%	0.20%	32.79%	3.89%	5.39%	7.76%
Equity Ratio	724	11.61%	12.94%	2.94%	99.05%	6.01%	8.78%	12.74%
Liquidity Ratio	724	18.26%	18.69%	0.47%	99.38%	6.50%	10.71%	21.48%
Cost-to-income Ratio	724	67.00%	15.63%	3.07%	98.75%	57.07%	67.14%	78.43%
Non-interest Income Ratio	705	41.23%	22.41%	-50.44%	105.88%	25.59%	40.84%	49.97%
Fees & Commissions Ratio	705	1.63%	4.59%	0.00%	61.59%	0.29%	0.65%	1.25%
Interest Income Ratio	705	2.24%	1.31%	0.36%	10.90%	1.23%	2.17%	2.89%
Interest Expenses Ratio	705	0.74%	0.65%	0.01%	4.57%	0.13%	0.57%	1.21%
Net Interest Margin	705	1.73%	1.11%	0.12%	7.86%	1.19%	1.49%	1.91%
One over Pretax Profit	724	1.27E-04	5.46E-04	7.44E-09	6.37E-03	5.79E-06	1.62E-05	5.78E-05
STR	724	28.75%	4.31%	15.00%	33.99%	25.00%	30.86%	31.40%
GDP Growth	724	1.64	0.91	-0.36	5.75	0.96	1.74	2.23
Inflation	724	0.66	0.88	-1.14	3.55	0.04	0.47	1.01

Control Group pre-NIR								
	Count	Mean	SD	Min	Max	p25	p50	p75
GAAP ETR	367	23.24%	12.83%	0.00%	100.00%	18.89%	24.78%	27.71%
Size	367	14.70	2.94	8.44	24.48	13.15	14.88	15.86
ROAE	367	9.22%	6.85%	0.20%	32.79%	4.87%	7.70%	11.78%
Equity Ratio	367	19.25%	27.69%	2.94%	99.21%	5.78%	7.80%	13.40%
Liquidity Ratio	367	22.73%	28.22%	0.47%	99.38%	4.66%	10.90%	26.44%
Cost-to-income Ratio	367	61.20%	21.78%	3.07%	98.75%	46.32%	65.96%	77.76%
Non-interest Income Ratio	345	29.42%	39.04%	-181.13%	147.58%	9.98%	22.60%	51.33%
Fees & Commissions Ratio	345	3.62%	11.82%	0.00%	61.59%	0.14%	0.37%	1.16%
Interest Income Ratio	345	4.43%	3.14%	0.36%	15.96%	2.90%	3.74%	5.24%
Interest Expenses Ratio	345	2.12%	1.25%	0.00%	4.88%	1.32%	2.09%	2.92%
Net Interest Margin	345	2.59%	2.92%	0.12%	14.21%	1.13%	1.89%	2.60%
One over Pretax Profit	367	8.16E-04	2.70E-03	7.44E-09	1.33E-02	1.08E-05	5.18E-05	2.66E-04
STR	367	25.82%	3.19%	18.50%	30.00%	24.20%	26.00%	28.00%
GDP Growth	367	2.70	1.05	-0.48	8.49	2.29	2.58	2.87
Inflation	367	2.31	1.45	0.05	8.89	1.45	1.91	2.91

Control Group post-NIR								
	Count	Mean	SD	Min	Max	p25	p50	p75
GAAP ETR	418	23.49%	11.79%	0.00%	100.00%	20.27%	24.56%	27.29%
Size	418	14.99	3.06	8.44	24.48	13.36	14.78	16.02
ROAE	418	8.91%	6.41%	0.20%	32.79%	4.83%	7.34%	10.92%
Equity Ratio	418	18.22%	25.67%	2.94%	99.21%	6.40%	7.97%	12.90%
Liquidity Ratio	418	20.78%	26.61%	0.47%	99.38%	4.33%	10.21%	23.25%
Cost-to-income Ratio	418	62.50%	22.20%	3.07%	98.75%	51.22%	67.95%	78.92%
Non-interest Income Ratio	386	30.20%	33.33%	-112.05%	125.04%	9.89%	21.72%	44.96%
Fees & Commissions Ratio	386	2.96%	9.93%	0.00%	61.59%	0.09%	0.34%	0.98%
Interest Income Ratio	386	3.96%	2.99%	0.36%	15.96%	2.54%	3.30%	4.36%
Interest Expenses Ratio	386	1.70%	1.07%	0.00%	4.88%	1.04%	1.58%	2.14%
Net Interest Margin	386	2.53%	2.67%	0.12%	14.21%	1.39%	1.92%	2.53%
One over Pretax Profit	418	5.85E-04	2.23E-03	7.44E-09	1.33E-02	9.00E-06	5.15E-05	1.97E-04
STR	418	25.34%	3.76%	19.00%	30.00%	22.00%	26.50%	26.50%
GDP Growth	418	2.25	1.14	0.69	7.47	1.11	2.36	2.98
Inflation	418	1.79	1.60	-0.87	11.14	1.13	1.43	1.94

Notes: Panel B shows descriptive statistics of the treatment group and control before and after the introduction of NIR separately. All variables are as defined in Appendix C.

Panel C: Treatment v.s. Control Groups

	Treatment					Control				
	Count	SD	Min	Max	p50	Count	SD	Min	Max	p50
GAAP ETR	1,442	15.59%	0.00%	100.00%	30.24%	785	12.28%	0.00%	100.00%	24.63%
Size	1,442	2.67	8.44	24.48	16.28	785	3.01	8.44	24.48	14.8
ROAE	1,442	4.47%	0.20%	32.79%	5.08%	785	6.62%	0.20%	32.79%	7.64%
Equity Ratio	1,442	12.17%	2.94%	99.05%	7.15%	785	26.62%	2.94%	99.21%	7.90%
Liquidity Ratio	1,442	18.15%	0.47%	99.38%	9.72%	785	27.38%	0.47%	99.38%	10.73%
Cost-to-income Ratio	1,442	14.94%	3.07%	98.75%	69.12%	785	22.00%	3.07%	98.75%	67.11%
Non-interest Income Ratio	1,411	22.38%	-50.44%	105.88%	35.12%	731	36.12%	-181.13%	147.58%	21.83%
Fees & Commissions Ratio	1,411	4.50%	0.00%	61.59%	0.46%	731	10.86%	0.00%	61.59%	0.36%
Interest Income Ratio	1,411	1.32%	0.36%	10.90%	1.81%	731	3.07%	0.36%	15.96%	3.53%
Interest Expenses Ratio	1,411	0.77%	0.01%	4.59%	0.41%	731	1.18%	0.00%	4.88%	1.77%
Net Interest Margin	1,411	0.99%	0.12%	8.12%	1.50%	731	2.79%	0.12%	14.21%	1.91%
One over Pretax Profit	1,442	5.25E-04	7.44E-09	8.70E-03	1.45E-05	785	2.46E-03	7.44E-09	1.33E-02	5.18E-05
STR	1,442	5.25%	15.00%	40.69%	30.86%	785	3.51%	18.50%	30.00%	26.50%
GDP Growth	1,442	1.07	-2.98	5.75	1.22	785	1.12	-0.48	8.49	2.37
Inflation	1,442	1.04	-1.14	3.55	0.56	785	1.55	-0.87	11.14	1.6

	Treatment-Mean	Control-Mean	Difference		t-stat
GAAP ETR	30.52%	23.37%	7.14%	***	11.89
Size	16.52	14.85	1.67	***	12.97
ROAE	6.14%	9.06%	-2.91%	***	11.04
Equity Ratio	10.36%	18.70%	-8.34%	***	-8.32
Liquidity Ratio	16.95%	21.69%	-4.74%	***	-4.36
Cost-to-income Ratio	68.03%	61.89%	6.14%	***	6.99
Non-interest Income Ratio	36.89%	29.83%	7.06%	***	-4.83
Fees & Commissions Ratio	1.45%	3.27%	-1.82%	***	-4.34
Interest Income Ratio	2.22%	4.18%	-1.96%	***	-16.49
Interest Expenses Ratio	0.75%	1.90%	-1.15%	***	-23.87
Net Interest Margin	1.68%	2.56%	-0.88%	***	-8.23
One over Pretax Profit	1.11E-04	6.93E-04	-5.82E-04	***	-6.54
STR	31.07%	25.56%	5.50%	***	29.49
GDP Growth	1.27	2.46	-1.19	***	-24.3
Inflation	0.93	2.03	-1.1	***	-17.8

Notes: Panel C shows descriptive statistics of the treatment group and the control group separately. The last two columns show differences between the mean and t-statistics. ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively. All variables are as defined in Appendix C.

Panel D: Correlation

Variables	*GAAP ETR*	*Size*	*ROAE*	*Equity Ratio*	*Liquidity Ratio*	*Cost-to-income Ratio*	*STR*	*GDP Growth*	*Inflation*
GAAP ETR	1.000								
Size	0.056*	1.000							
ROAE	-0.310*	-0.184*	1.000						
Equity Ratio	-0.123*	-0.413*	0.117*	1.000					
Liquidity Ratio	-0.105*	0.018	0.083*	0.233*	1.000				
Cost-to-income Ratio	0.185*	0.058*	-0.370*	-0.163*	-0.146*	1.000			
STR	0.338*	0.263*	-0.291*	-0.162*	-0.110*	0.194*	1.000		
GDP Growth	-0.236*	-0.145*	0.245*	0.136*	0.055*	-0.081*	-0.418*	1.000	
Inflation	-0.146*	-0.218*	0.235*	0.171*	0.084*	-0.129*	-0.288*	0.302*	1.000

Notes: This table presents Pearson correlation coefficients in the lower diagonal. * indicates the correlation coefficients are significant at the .05 level or higher. All variables are as defined in Appendix C.

Table 3: Main Difference-in-Difference Regression

VARIABLES	(1) ETR	(2) ETR	(3) ETR	(4) ETR
*Treat*Post*	-0.0258**	-0.0258**	-0.0230*	-0.0231*
	(0.0122)	(0.0119)	(0.0123)	(0.0120)
Size	0.0482*	0.0481*	0.0533*	0.0534*
	(0.0279)	(0.0282)	(0.0295)	(0.0299)
ROAE	-1.186***	-1.187***	-1.297***	-1.295***
	(0.152)	(0.147)	(0.172)	(0.168)
Equity Ratio	0.492	0.493	0.468	0.466
	(0.353)	(0.352)	(0.413)	(0.414)
Liquidity Ratio	-0.0269	-0.0271	-0.0255	-0.0252
	(0.0643)	(0.0636)	(0.0672)	(0.0668)
Cost-to-income Ratio	-0.206***	-0.205***	-0.227***	-0.229***
	(0.0588)	(0.0601)	(0.0625)	(0.0648)
Non-interest Income Ratio			-0.0507	-0.0506
			(0.0400)	(0.0402)
Fees & Commissions Ratio			0.973	0.971
			(0.604)	(0.603)
Interest Income Ratio			-0.221	-0.220
			(2.534)	(2.539)
Interest Expenses Ratio			0.700	0.707
			(2.735)	(2.739)
Net Interest Margin			0.496	0.494
			(2.069)	(2.072)
STR	0.433**	0.432**	0.424*	0.425*
	(0.213)	(0.214)	(0.240)	(0.241)
GDP Growth	-0.000582	-0.000583	-0.00174	-0.00174
	(0.00279)	(0.00279)	(0.00282)	(0.00282)
Inflation	0.00563	0.00564	0.00593	0.00590
	(0.00439)	(0.00432)	(0.00438)	(0.00431)
One over Pretax Profit		-0.505		1.416
		(15.59)		(11.55)
Constant	-0.448	-0.447	-0.513	-0.515
	(0.478)	(0.482)	(0.511)	(0.516)
Observations	2,227	2,227	2,142	2,142
R-squared	0.155	0.155	0.166	0.166
Number of banks	404	404	385	385
year FE	yes	yes	yes	yes
bank FE	yes	yes	yes	yes

Notes: This table presents the results of a staggered difference-in-differences analysis on the full sample. We require banks to have at least one observation pre-adoption and one observation post-adoption (post-adoption starts 2015 for banks in the control group).

We estimate the following model: $ETR_{ijt} = \beta_0 + \beta_1 Treat_{ij} * Post_t + \delta X_{ijt} + \mu_i + \theta_t + \varepsilon_{ijt}$

The dependent variable is *ETR* measured as tax expense scaled by pre-tax income. Treat*Post equals to one if (1) the bank is in the country with negative interest rate policy (2) during and after a negative interest rate policy is adopted, and zero otherwise. Column (1) and (2) controls for possibilities and pressure of tax planning, capital structure, risks and operating efficiency. Column (3) and (4) add additional control variables regarding banks' business models and

risks. *ETR*s are winsorized at 0 and 1. All other variables are winsorized at the 1% and 99% level. Variables are defined in Appendix C. All regressions include bank fixed effects and year fixed effects. Robust standard errors clustered by bank in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 4: Robustness Tests: Alternative Control Samples

VARIABLES	(1) U.S. Included	(2) U.S. Included	(3) Japan Excluded	(4) Japan Excluded	(5) GUO	(6) GUO	(7) Adoption Year Excluded	(8) Adoption Year Excluded	(9) Alternative Controls
*Treat*Post*	-0.0414***	-0.0392***	-0.0297**	-0.0255*	-0.0313**	-0.0299*	-0.0447***	-0.0416***	-0.0284***
	(0.0107)	(0.0114)	(0.0140)	(0.0144)	(0.0155)	(0.0153)	(0.0141)	(0.0144)	(0.0109)
Size	0.0238**	0.0318***	0.0410	0.0545*	0.0457	0.0698**	0.0520*	0.0550*	0.0452
	(0.0102)	(0.0110)	(0.0299)	(0.0322)	(0.0317)	(0.0343)	(0.0311)	(0.0324)	(0.0275)
ROAE	-1.227***	-1.318***	-0.948***	-1.028***	-1.415***	-1.571***	-1.065***	-1.158***	-0.0141***
	(0.0604)	(0.0630)	(0.170)	(0.194)	(0.182)	(0.207)	(0.157)	(0.179)	(0.00192)
Equity Ratio	-0.0589	-0.169	0.511	0.528	-0.0760	-0.318	0.595*	0.575	0.00438
	(0.220)	(0.252)	(0.345)	(0.397)	(0.245)	(0.327)	(0.325)	(0.370)	(0.00419)
Liquidity Ratio	-0.0608*	-0.0403	0.000323	-0.0167	-0.0858	-0.0952	-0.0153	-0.0197	-0.000328
	(0.0329)	(0.0331)	(0.0732)	(0.0770)	(0.0829)	(0.0880)	(0.0768)	(0.0813)	(0.000670)
Cost-to-income Ratio	-0.496***	-0.479***	-0.127**	-0.139**	-0.224***	-0.282***	-0.189***	-0.219***	-0.00281***
	(0.0318)	(0.0325)	(0.0636)	(0.0682)	(0.0808)	(0.0820)	(0.0649)	(0.0709)	(0.000693)
Non-interest Income Ratio		0.0246		-0.0502		-0.110		-0.0530	-0.000373
		(0.0271)		(0.0406)		(0.0762)		(0.0423)	(0.000406)
Fees & Commissions Ratio		0.440*		0.961**		2.665***		1.201**	0.00946
		(0.256)		(0.438)		(0.819)		(0.516)	(0.00622)
Interest Income Ratio		0.779		0.490		2.640		-1.579	0.00288
		(0.912)		(2.440)		(3.047)		(2.785)	(0.0258)
Interest Expenses Ratio		-1.144		-0.212		-2.389		1.834	0.00463
		(1.413)		(2.676)		(3.323)		(2.989)	(0.0277)
Net Interest Margin		2.064***		-0.138		-3.033		1.281	0.00619
		(0.692)		(1.814)		(3.290)		(2.199)	(0.0210)
STR	0.813***	0.772***	0.696*	0.666*	0.236	0.177	0.580**	0.527**	0.413*
	(0.208)	(0.224)	(0.388)	(0.391)	(0.236)	(0.286)	(0.244)	(0.261)	(0.234)
GDP Growth	-0.00356	-0.00416	-0.00214	-0.00421	0.000468	-0.000644	0.00416	0.00278	
	(0.00276)	(0.00283)	(0.00324)	(0.00330)	(0.00386)	(0.00402)	(0.00325)	(0.00331)	
Inflation	-0.000543	-5.13e-05	0.00724	0.00715	0.00616	0.00639	0.0106**	0.0109**	
	(0.00334)	(0.00334)	(0.00505)	(0.00518)	(0.00553)	(0.00562)	(0.00468)	(0.00467)	

Credit Risk Ratio									-0.0552**
									(0.0233)
Off-balance Sheet Ratio									0.000314
									(0.000513)
Constant	0.0530	-0.132	-0.460	-0.651	-0.239	-0.514	-0.602	-0.607	-0.336
	(0.186)	(0.193)	(0.524)	(0.564)	(0.525)	(0.597)	(0.536)	(0.562)	(0.471)
Observations	13,409	13,296	1,631	1,552	1,479	1,425	1,839	1,772	2,142
R-squared	0.182	0.190	0.122	0.139	0.195	0.212	0.173	0.184	0.170
Number of banks	2,204	2,180	308	290	259	248	404	385	385
year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
bank FE	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: This table presents the results of robustness tests.

We estimate the following model: $ETR_{ijt} = \beta_0 + \beta_1 Treat_{ij} * Post_t + \delta X_{ijt} + \mu_i + \theta_t + \varepsilon_{ijt}$

The dependent variable is *ETR* measured as tax expense scaled by pre-tax income. Treat*Post equals to one if (1) the bank is in the country with negative interest rate policy (2) during and after a negative interest rate policy is adopted, and zero otherwise. Column (1) and (2) show results of regressions including U.S. banks in the sample. Column (3) and (4) shows results of regressions excluding Japanese banks in the sample. Column (5) and (6) present results for tests on banks identified as global ultimate owners, excluding banks classified as "independent company" or "single location". Column (7) and (8) present results excluding the adoption year. In column (9), we add additional control for credit risk (the ratio of loan loss provisions on total assets) and off-balance sheet ratio (the ratio of off-balance sheet items on total assets). We set credit risk to zero if data is missing or negative. We set off-balance sheet ratio to zero if missing. *ETR*s are winsorized at 0 and 1. All other variables are winsorized at the 1% and 99% level. Variables are defined in Appendix C. All regressions include bank fixed effects and year fixed effects. Robust standard errors clustered by bank in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 5: Robustness Tests: Event-based Difference-in-Difference

VARIABLES	(1) Aligned DID	(2) Aligned DID	(3) PSM-Matched Sample	(4) PSM-Matched Sample
*Treat*Post*	-0.0217*	-0.0207*	-0.0224*	-0.0254*
	(0.0114)	(0.0115)	(0.0119)	(0.0129)
Size	0.0305	0.0374	-0.000319	0.0263
	(0.0272)	(0.0274)	(0.0219)	(0.0306)
ROAE	-1.164***	-1.319***	-1.273***	-1.368***
	(0.176)	(0.197)	(0.217)	(0.210)
Equity Ratio	0.370	0.344	0.255	-0.452
	(0.320)	(0.380)	(0.386)	(0.346)
Liquidity Ratio	-0.0319	-0.0444	-0.0121	-0.169
	(0.0723)	(0.0737)	(0.138)	(0.205)
Cost-to-income Ratio	-0.194***	-0.218***	-0.242***	-0.223**
	(0.0548)	(0.0590)	(0.0812)	(0.0905)
Non-interest Income Ratio		-0.0429		-0.0335
		(0.0348)		(0.117)
Fees & Commissions Ratio		0.559		0.705
		(0.517)		(0.949)
Interest Income Ratio		0.634		-1.671
		(2.266)		(2.061)
Interest Expenses Ratio		1.223		2.842
		(2.522)		(2.099)
Net Interest Margin		0.147		5.114
		(1.873)		(3.770)
STR	0.484**	0.493**	0.617***	0.500***
	(0.223)	(0.243)	(0.149)	(0.175)
GDP Growth	-0.00396	-0.00474	-0.00364	-0.00951*
	(0.00334)	(0.00348)	(0.00519)	(0.00560)
Inflation	0.00512	0.00537	0.00277	0.00202
	(0.00442)	(0.00487)	(0.00528)	(0.00502)
Constant	-0.158	-0.279	0.375	0.0126
	(0.476)	(0.482)	(0.364)	(0.487)
Observations	2,323	2,226	1,438	1,217
R-squared	0.131	0.146	0.183	0.199
Number of banks	425	405	252	212
year FE	yes	yes	yes	yes
bank FE	yes	yes	yes	yes

Notes: This table presents the results of robustness tests.
We estimate the following model: $ETR_{ijt} = \beta_0 + \beta_1 Treat_{ij} * Post_t + \delta X_{ijt} + \mu_i + \theta_t + \varepsilon_{ijt}$
The dependent variable is *ETR* measured as tax expense scaled by pre-tax income. Treat*Post equals to one if (1) the bank is in the country with negative interest rate policy (2) during and after a negative interest rate policy is adopted, and zero otherwise. Column (1) and (2) use aligned difference-in-difference design. Column (3) and (4) use aligned difference-in-difference for propensity score-matched samples based on *Size*, *ROAE*, equity ratio and liquidity. We perform 1 to 1 nearest neighbor matching within caliper width without replacement. *ETR*s are winsorized at 0 and 1. All other variables are winsorized at the 1% and 99% level. Variables are defined in Appendix C. All regressions include bank fixed effects and year fixed effects.

Robust standard errors clustered by bank in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 6: Falsification Test

VARIABLES	(1) ETR	(2) ETR	(3) ETR	(4) ETR
*Treat*Post*	-0.0192	-0.0191	-0.017	-0.0171
	-0.013	-0.0128	-0.0135	-0.0132
Size	0.0493*	0.0493*	0.0544*	0.0545*
	-0.0277	-0.0281	-0.0293	-0.0297
ROAE	-1.187***	-1.188***	-1.296***	-1.294***
	-0.152	-0.146	-0.172	-0.168
Equity Ratio	0.494	0.495	0.468	0.467
	-0.355	-0.354	-0.416	-0.417
Liquidity Ratio	-0.0268	-0.0271	-0.0256	-0.0253
	-0.0652	-0.0645	-0.068	-0.0676
Cost-to-income Ratio	-0.208***	-0.207***	-0.229***	-0.231***
	-0.0587	-0.0599	-0.0623	-0.0644
Non-interest Income Ratio			-0.0516	-0.0515
			-0.0403	-0.0404
Fees & Commissions Ratio			1.001*	1.000*
			-0.604	-0.602
Interest Income Ratio			-0.277	-0.275
			-2.507	-2.511
Interest Expenses Ratio			0.726	0.732
			-2.715	-2.718
Net Interest Margin			0.552	0.551
			-2.038	-2.04
STR	0.417*	0.417*	0.408	0.408
	-0.236	-0.238	-0.265	-0.267
GDP Growth	-0.00287	-0.00287	-0.00381	-0.00382
	-0.00292	-0.00292	-0.00295	-0.00294
Inflation	0.00715*	0.00716*	0.00729*	0.00727*
	-0.00416	-0.00411	-0.00414	-0.00409
One over Pretax Profit		-0.851		1.183
		-15.69		-11.62
Constant	-0.458	-0.457	-0.523	-0.525
	-0.477	-0.482	-0.511	-0.515
Observations	2,227	2,227	2,142	2,142
R-squared	0.152	0.153	0.164	0.165
Number of banks	404	404	385	385
year FE	yes	yes	yes	yes
bank FE	yes	yes	yes	yes

Notes: This table presents the results of falsification tests.
We estimate the following model: $ETR_{ijt} = \beta_0 + \beta_1 Treat_{ij} * Post_t + \delta X_{ijt} + \mu_i + \theta_t + \varepsilon_{ijt}$
Treat*Post equals one if interest rate <0.05 instead of negative, and zero otherwise. The dependent variable is *ETR* measured as tax expense scaled by pre-tax income. . Column (1) and (2) controls for possibilities and pressure of tax planning, capital structure, risks and operating efficiency. Column (3) and (4) add additional control variables regarding banks' business models and risks. *ETR*s are winsorized at 0 and 1. All other variables are winsorized at the 1% and 99% level. Variables are defined in Appendix BAppendix C. All regressions include bank fixed effects and year fixed effects. Robust standard errors clustered by bank in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 7: Cross-sectional Test: Distance to Insolvency

VARIABLES	(1) Low Distance to Insolvency	(2) High Distance to Insolvency	(3) Low Distance to Insolvency	(4) High Distance to Insolvency
*Treat*Post*	-0.0419**	0.00344	-0.0410**	0.00408
	(0.0166)	(0.0201)	(0.0168)	(0.0207)
Size	0.0217	0.0788	0.0336	0.0754
	(0.0315)	(0.0534)	(0.0354)	(0.0532)
ROAE	-1.145***	-1.640***	-1.234***	-1.955***
	(0.183)	(0.410)	(0.204)	(0.474)
Equity Ratio	0.685*	0.457	0.692*	0.217
	(0.353)	(0.372)	(0.398)	(0.543)
Liquidity Ratio	-0.0708	0.108	-0.0614	0.123
	(0.0818)	(0.0980)	(0.0897)	(0.0877)
Cost-to-income Ratio	-0.357***	-0.117	-0.352***	-0.170
	(0.0841)	(0.115)	(0.0876)	(0.125)
Non-interest Income Ratio			-0.0129	-0.0770
			(0.0443)	(0.0957)
Fees & Commissions Ratio			0.652	1.804***
			(0.512)	(0.352)
Interest Income Ratio			0.694	3.064
			(3.186)	(5.020)
Interest Expenses Ratio			-0.629	-0.198
			(3.205)	(5.545)
Net Interest Margin			-0.605	-0.0722
			(2.609)	(4.541)
STR	0.159	0.609**	0.110	0.769**
	(0.344)	(0.278)	(0.372)	(0.334)
GDP Growth	-0.00137	-0.00156	-0.00333	-0.00148
	(0.00506)	(0.00318)	(0.00511)	(0.00325)
Inflation	-0.00269	0.0128*	-0.00141	0.0120*
	(0.00505)	(0.00748)	(0.00537)	(0.00721)
Constant	0.170	-1.096	-0.00514	-1.101
	(0.515)	(0.901)	(0.572)	(0.929)
Observations	869	814	840	781
R-squared	0.207	0.143	0.216	0.186
Number of banks	140	140	134	134
year FE	yes	yes	yes	yes
bank FE	yes	yes	yes	yes

Notes: This table presents the results of a staggered difference-in-differences analysis when splitting the sample into low and high distance to insolvency, proxied by Z-score. A high Distance to Insolvency indicates that there is more room for returns fall to wipe out all equity and thus is an indication for stability. We split banks in the treatment group and banks in the control

group together using the median Distance to Insolvency per country of the year before the adoption of a negative interest rate (we use the year 2015 for the control group). We drop countries with only one bank.

We estimate the following model for two subgroups respectively: $ETR_{ijt} = \beta_0 + \beta_1 Treat_{ij} * Post_t + \delta X_{ijt} + \mu_i + \theta_t + \varepsilon_{ijt}$

The dependent variable is *ETR* measured as tax expense scaled by pre-tax income. Treat*Post equals to one if (1)the bank is in the country with negative interest rate policy (2) during and after a negative interest rate policy is adopted, and zero otherwise. Column (1) and (2) controls for possibilities and pressure of tax planning, capital structure, risks and operating efficiency. Column (3) and (4) add additional control variables regarding business model. *ETR*s are winsorized at 0 and 1. All other variables are winsorized at the 1% and 99% level. Variables are defined in Appendix C. All regressions include bank fixed effects and year fixed effects. Robust standard errors clustered by bank in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 8: Cross-sectional Test: Level of Reserves

VARIABLES	(1) Low Reserve (Low *Cash at Central Bank*)	(2) High Reserve (High *Cash at Central Bank*)	(3) Low Reserve (Low *Cash at Central Bank*)	(4) High Reserve (High *Cash at Central Bank*)
*Treat*Post*	-0.0411***	0.00109	-0.0421***	-0.00112
	(0.0126)	(0.0229)	(0.0128)	(0.0214)
Size	0.0142	0.0850**	0.0129	0.0956**
	(0.0273)	(0.0419)	(0.0269)	(0.0456)
ROAE	-0.955***	-1.466***	-1.038***	-1.682***
	(0.174)	(0.249)	(0.185)	(0.285)
Equity Ratio	-0.225	-0.00596	-0.473**	-0.422
	(0.186)	(0.247)	(0.229)	(0.290)
Liquidity Ratio	-0.118	0.0375	-0.131*	0.0287
	(0.0741)	(0.0772)	(0.0712)	(0.0848)
Cost-to-income Ratio	-0.0976	-0.378***	-0.111	-0.397***
	(0.0711)	(0.0901)	(0.0745)	(0.0919)
Non-interest Income Ratio			-0.0556	0.0757
			(0.0430)	(0.101)
Fees & Commissions Ratio			1.645***	1.299**
			(0.459)	(0.630)
Interest Income Ratio			3.544	2.072
			(2.768)	(3.116)
Interest Expenses Ratio			-4.766*	-0.636
			(2.842)	(3.416)
Net Interest Margin			-1.204	-0.306
			(2.471)	(2.691)
STR	0.257	0.424	0.124	0.503
	(0.256)	(0.329)	(0.269)	(0.371)
GDP Growth	0.000224	-0.00165	-0.00110	-0.00217
	(0.00391)	(0.00499)	(0.00403)	(0.00482)
Inflation	0.00191	0.00611	0.00140	0.00483
	(0.00448)	(0.00837)	(0.00437)	(0.00812)
Constant	0.169	-0.859	0.236	-1.093
	(0.427)	(0.724)	(0.422)	(0.823)
Observations	1,074	987	1,030	952
R-squared	0.129	0.209	0.152	0.226
Number of banks	184	184	175	175
year FE	yes	yes	yes	yes
bank FE	yes	yes	yes	yes

Notes: This table presents the results of a staggered difference-in-differences analysis when splitting the sample into low and high reserve measured as cash at central bank. We split banks in the treatment group and banks in the control group together using the median reserve per country of the year before the adoption of a negative interest rate (we use year 2015 for the control group). We drop countries with only one bank.
We estimate the following model for two subgroups respectively: $ETR_{ijt} = \beta_0 + \beta_1 Treat_{ij} * Post_t + \delta X_{ijt} + \mu_i + \theta_t + \varepsilon_{ijt}$
The dependent variable is *ETR* measured as tax expense scaled by pre-tax income. Treat*Post equals to one if (1) the bank is in the country with negative interest rate policy (2) during and after a negative interest rate policy is adopted, and zero otherwise. Column (1) and (2) controls for possibilities and pressure of tax planning, capital structure, risks and operating efficiency. Column (3) and (4) add additional control variables regarding business model. *ETR*s are winsorized at 0 and 1. All other variables are winsorized at the 1% and 99% level. Variables are defined in Appendix C. All regressions include bank fixed effects and year fixed effects. Robust standard errors clustered by bank in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 9: Cross-sectional Test: Tax Enforcement

VARIABLES	(9) Low Enforcement	(10) High Enforcement	(11) Low Enforcement	(12) High Enforcement
*Treat*Post*	-0.0389***	-0.0209	-0.0385***	-0.0171
	(0.0142)	(0.0181)	(0.0141)	(0.0180)
Size	0.0429	0.0384	0.0366	0.0592
	(0.0349)	(0.0356)	(0.0355)	(0.0384)
ROAE	-1.226***	-1.248***	-1.280***	-1.445***
	(0.174)	(0.239)	(0.187)	(0.278)
Equity Ratio	0.848***	-0.335*	0.845***	-0.499**
	(0.266)	(0.180)	(0.267)	(0.229)
Liquidity Ratio	-0.0992	-0.0588	-0.0787	-0.0825
	(0.0661)	(0.0836)	(0.0772)	(0.0886)
Cost-to-income Ratio	-0.231***	-0.182**	-0.256***	-0.225**
	(0.0753)	(0.0852)	(0.0754)	(0.0892)
Non-interest Income Ratio			-0.173**	-0.0125
			(0.0825)	(0.0426)
Fees & Commissions Ratio			-0.167	1.841***
			(0.605)	(0.424)
Interest Income Ratio			-1.491	3.105
			(2.226)	(3.678)
Interest Expenses Ratio			2.679	-3.079
			(2.165)	(4.139)
Net Interest Margin			1.393	-1.830
			(1.668)	(3.121)
STR	0.186	0.839	0.212	0.766
	(0.286)	(0.746)	(0.313)	(0.731)
GDP Growth	-6.01e-05	-0.00458	-0.000509	-0.00545
	(0.00534)	(0.00408)	(0.00557)	(0.00405)
Inflation	0.00496	0.00802	0.00475	0.00511
	(0.00529)	(0.0123)	(0.00543)	(0.0131)
Constant	-0.322	-0.255	-0.154	-0.538
	(0.586)	(0.637)	(0.578)	(0.692)
Observations	1,074	1,153	1,041	1,101
R-squared	0.229	0.132	0.243	0.160
Number of banks	194	210	186	199
year FE	yes	yes	yes	yes
bank FE	yes	yes	yes	yes

Notes: This table presents the results of a staggered difference-in-differences analysis when splitting the sample into low and high tax enforcement. We split banks in the treatment group and banks in the control group together using

the median of enforcement divided by GDP in 2011, the first year in the sample. We drop countries with only one bank.

We estimate the following model for two subgroups respectively: $ETR_{ijt} = \beta_0 + \beta_1 Treat_{ij} * Post_t + \delta X_{ijt} + \mu_i + \theta_t + \varepsilon_{ijt}$

The dependent variable is *ETR* measured as tax expense scaled by pre-tax income. Treat*Post equals to one if (1) the bank is in the country with negative interest rate policy (2) during and after a negative interest rate policy is adopted, and zero otherwise. Column (1) and (2) controls for possibilities and pressure of tax planning, capital structure, risks and operating efficiency. Column (3) and (4) add additional control variables regarding business model. *ETR*s are winsorized at 0 and 1. All other variables are winsorized at the 1% and 99% level. Variables are defined in Appendix C. All regressions include bank fixed effects and year fixed effects. Robust standard errors clustered by bank in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively.