Sovereign Debt Holding and Bank Sensitivity toward Market Risk: An Alternative View of the Bank–Sovereign Problem*

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Government bonds have always been a popular type of investment for banks. However, this trend has been further enhanced by the provisions of numerous banking regulations aimed at promoting investment in these securities. We empirically test the role of the fiscal incentive provided by Polish authorities aimed at encouraging banks to invest in sovereign debt. Additionally, we verify whether and how increased sovereign debt holding has exposed banks to fair-value accounting and test the consequent market risk related to such investment. To this end, we use unique quarterly balance sheet data on sovereign holdings at Polish banks for the period from 2008:Q1 to 2017:Q4, organized in line with International Financial Reporting Standards (IFRS) as "*available for sale,*" "*held for trading,*" and "*held to maturity.*" Our regression results evidence that fiscal incentives greatly increase banks' bias towards sovereign debt while reducing other investment. More importantly, our findings document that banks have enlarged the share of

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sovereign debt heavily exposed to market changes, primarily holding it under "*available for sale.*" Our stress tests document that a yield curve shock might leave less-capitalized banks with the shortage of regulatory capital. Our findings seem particularly important today, in the context of the COVID-19 pandemic, when the deteriorating fiscal situation of many countries may give a rise to a bond-yield shock and force banks to include potential losses in the regulatory capital.

JEL Codes: E43, E44, E47, E58, G21, G28, H6.

1. Introduction

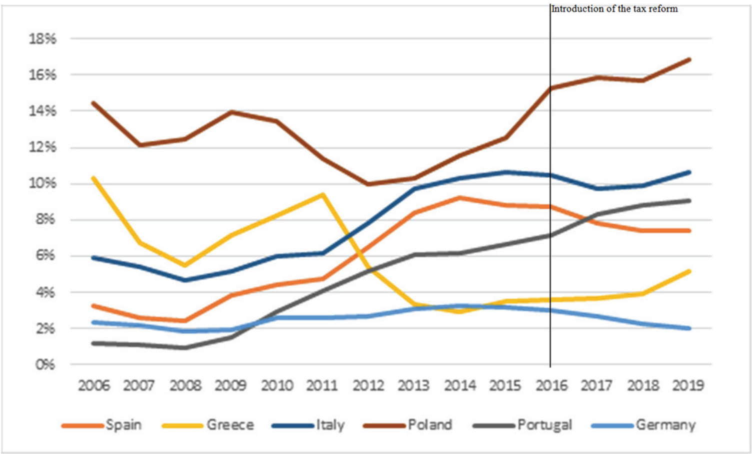
Bank distress may have severe consequences not only for the stability of the financial system but also for the real economy, public finances, and society. In some countries, fiscal costs of systemic banking crises have reached up to 7 percent of the gross domestic product (GDP), while output has fallen by 23 percent compared with long-term trends (Laeven and Valencia 2012). Banks' extensive investment in sovereign debt posed a grave risk to the European banking sector during the recent financial crisis of 2010 (Acharya and Steffen 2015).

Investment in government bonds has always been popular with banks. In Europe, government bonds account for 80 percent of banks' total financial investments (Argimón, Dietsch, and Estrada 2018). Since the 2008 crisis, the share of sovereign debt in banks' balance sheet has increased significantly in the majority of European countries, although figures vary significantly between countries. Interestingly, Poland has the highest share of domestic sovereign debt[1] (17 percent of banks' total assets). In Germany, in turn, this share stands at 2.5 percent, while in Italy it accounts for 11 percent of banks' total assets (Figure 1; for figures in color, see the online version of the paper at http://www.ijcb.org).

The literature proposes four non-mutually exclusive explanations for why banks decide to hold sovereign debt. First, as government bonds are typically safe and liquid, they are highly eligible

[1] Poland and Hungary have the highest share of government debt among all European countries (European Central Bank 2019).

Figure 1. Government Debt Holding by Domestic Banks in Europe



Source: European Central Bank.

as collateral (Krishnamurthy and Vissing-Jorgensen 2012). Second, banks decide to invest in sovereign debt to profit from higher yields, especially during periods of uncertainty (Acharya and Steffen 2015; Andreeva and Vlassopoulos 2019), or in order to offset low interest income by higher trading income (Borio, Gambacorta, and Hofmann 2017; Claessens, Coleman, and Donnelly 2018; Molyneux et al. 2021). Banks may also purchase sovereign debt to increase the likelihood of their bailout in the event of a sovereign default (Farhi and Tirole 2018). Finally, there are implicit and explicit incentives of governments and regulators encouraging banks to hold sovereign debt (Popov and van Horen 2013; Boner 2016; Gennaioli, Martin, and Rossi 2018).

As for the latter, the current regulatory framework is undoubtedly the key driver behind banks' decision to invest in sovereign debt. A good example is Basel III, which was agreed upon in 2011 and became effective in Europe and the United States in 2014; it introduced a number of provisions under which government securities are treated as risk-free. The provisions specifically refer to the zero-capital weight for investment in European government securities, the absence of large government exposure limits, and the inclusion of government securities in liquidity ratios. Certain countries have gone further by offering additional national incentives to banks in an attempt to encourage them to hold sovereign debt. For example, Poland has offered fiscal incentives to banks, excluding government debt from the new bank taxation. These measures were to promote potentially safe investment as part of banks' balance sheet, while giving states and other public authorities privileged access to funding.

However, government debt is not risk-free: in the past, countries have defaulted on their obligations on several occasions, causing losses for investors. Consequently, extensive investment in government securities might entail significant risk for the banking sector. The European debt crisis has clearly illustrated how government credit risk might easily translate into banks' credit risk, leading to severe contagion effects between different countries (Bolton and Jeanne 2011; Lucas, Schwaab, and Zhang 2014; Breckenfelder and Schwaab 2018; or Kirchenmann, Korte, and Steffen 2020). However, bank risk is not only correlated with sovereign creditworthiness. In our paper we argue that additional risk, potentially threatening the stability of the banking sector, might come from the market. More specifically, we argue that the recent implementation of Basel III provisions that require the inclusion of unrealized current losses from market revaluation of "available-for-sale" investment into the regulatory tier 1 capital might lead to excessive balance sheet volatility and the procyclicality of regulatory capital ratios (Basel Committee on Banking Supervision 2015). More importantly, the new Basel III regulation removes prudential filters that allowed banks to exclude certain losses from banks' regulatory capital. Notwithstanding, this relatively new regulatory framework raises concerns about banks' investment in government securities, which constitute the bulk of financial instruments among bank assets, while exposing banks to excessive market risk, especially when they are classified under "*available for sale*" (AFS). Interestingly, this problem came to the fore in 2020, during the COVID-19 pandemic, when the European Union decided to introduce a "quick fix" amendment, allowing European banks to temporarily use prudential filters in order to neutralize the impact of the risk on banks' capital in asset revaluation.[2]

[2]For more information, please view https://ec.europa.eu/commission/presscorner/detail/en/ip_20_740.

Despite the recent increase in sovereign debt held by banks, academic knowledge about reasons and risks related to banks' investment in sovereign debt remains limited. Scholars have focused on regulatory incentives offered to banks with regard to the treatment of government securities in capital regulations (Popov and van Horen 2013; Boner 2016; Gennaioli, Martin, and Rossi 2018), while banking risk tends to be analyzed from the credit risk perspective (Acharya, Dreschler, and Schnabl 2014; Gennaioli, Martin, and Rossi 2014; Acharya and Steffen 2015; Sosa-Padilla 2018; or Andreeva and Vlassopoulos 2019). With our paper, we seek to contribute to the body of empirical studies in three fields. Firstly, we investigate the fiscal motive in banks' decision to invest in government debt. Secondly, we analyze how the tax reform has contributed to the change of banks' behavior in terms of accounting classification of their investment. Finally, we test the market risk related to the revaluation of debt securities given a potential shock in the yield curve and the accounting consequences of such a shock for banks' regulatory capital and profits given the recent changes in banks' investment behavior.

More specifically, in our study we examine the impact of the banking tax reform introduced in Poland that exempts sovereign debt from the new sectoral tax. This regulatory incentive is new and unique on the global scale, and therefore has yet to be thoroughly explored by scholars. In our paper, we analyze banks' reaction to it. Following the European sovereign crisis of 2011, the impact of regulatory incentives on banks' decision to hold sovereign debt became the focus of numerous studies; however, many questions remain unanswered. Poland is an ideal testing ground for our research questions because of the significant exposure of Polish banks to domestic sovereign debt, and to the favorable treatment of governments' securities from the point of view of taxation, thus far unobserved in other European countries.

To analyze the risk related to banks' increased investment in sovereign debt, we perform two arrays of analysis. Firstly, we investigate how banks classify their government securities in their accounting books and, more specifically, how the fiscal reform contributes to banks' accounting strategies. Banks' exposure to sovereign debt is measured on the basis of a mix of market and book values depending on their accounting classification: "*available for sale*" (AFS), "*held* *for trading*" (HFT), and "*held to maturity*" (HTM).[3] Although the HTM holdings need to be accounted at their amortized historical value, the AFS and HFT investments must be recorded at their fair value and "*mark-to-market.*" It is crucial how banks record their financial investment as, on the one hand, it indicates the role that these securities play in banks' operation and, on the other hand, it exposes banks to different sources of risk. In an attempt to answer our question, we used unique supervisory data of Polish banks spanning the period from 2008 to 2017. These data allow us to distinguish between different financial assets in banks' balance sheets, their accounting classification as well as their maturities and, consequently, to analyze micro and macro factors playing an important role in banks' accounting classification. Finally, we are interested in how banks' increased investment in sovereign debt exposes banks to the market risk as a result of the yield curve shock. We argue that the greater the share of government securities held under fair-value accounting as AFS or HFT, the higher the risk of potential revaluation, and therefore of a squeeze in banks' capital and earnings in the event of a potential market shock. To explore this hypothesis, we have introduced a novel market risk metric called the "shock-loss indicator of portfolio" (SLIP), a time-varying and bank-level stress-test indicator that measures the potential market loss resulting from an unfavorable change in the market value of Treasury securities in banks' financial portfolio. In particular, SLIP quantifies, for example, the impact of an increased credit risk of government bonds on banks' regulatory capital and profits during each quarter, while using supervisory data on the value of sovereign securities, their duration, and accounting type as well as the scale of the potential yield curve shock. In the baseline setup, we assume a 300 basis point (bp) upward shift in the yield curve, which is a common practice among central banks and supervisory authorities (BCBS 2016; Borsuk and Krzesicki 2020). Given that only investments under HFT and AFS

[3]The exact terms used in bank regulations differ across jurisdictions depending on the underlying accounting roles. For example, in IFRS 9, HFT corresponds to fair value through profit and loss (FVTPL), AFS is analogous to fair value through other comprehensive income (FVTOCI), and HTM to financial assets measured at amortized cost.

are sensitive to price changes, SLIP covers uniquely financial assets under these accounting classifications.

Our results indicate that fiscal incentives offered to banks have increased their exposure to government bonds. More specifically, our findings indicate that the tax reform resulted in an increase in the share of government bonds in banks' assets by around 6 percentage points. More importantly, our estimations show that banks have replaced the risk-free central banks' bills by interest rate sensitive government bonds. We have also found that banks might have reduced lending and used their funds to increase investment in government bonds. This confirms the hypothesis that banks invest in sovereign debt to decrease their tax burden, and subsequently to improve their performance. Consequently, our estimations document that the tax effect has been much more evident in the case of private banks than state-owned banks. We argue that this is because state-owned banks might be subject to a greater political pressure to perform their social mission and use deposit money for lending rather than investing in sovereign debt (Yang 2019). In turn, private banks, mostly foreign owned, might be more oriented towards performance maximization. Importantly, we argue that private banks tend to focus on reducing their tax burden through their investment in sovereign debt and, at the same time, on improving their performance.

In the second analysis, we have found that the new government tax incentive had not only led to a strong surge in banks' demand for tax-free sovereign bonds, but also increased the share of sovereign debt securities heavily exposed to market changes, primarily held under AFS. Interestingly, neither liquidity needs nor banks' capital level or the risk-free rate seem to be important variables determining banks' accounting decisions regarding the classification of financial assets. We argue that banks tend to favor the AFS portfolio because of its greater flexibility in comparison with HFT and HTM portfolios, at the cost of a higher volatility of profits and capital. Consequently, we find that the tax reform has significantly increased the share of AFS investment at banks.

Finally, we show that an increased investment in sovereign bonds exposes banks to a significant market risk. More importantly, regression results on our SLIP measure evidence that fiscal incentives make banks' asset structures significantly more sensitive to the yield curve shock. As a result, we observe that a 300 bp yield curve shock might squeeze banks' capital up to the level of 70 percent of banks' regulatory capital, even though the mean is 7 percent. We argue that this is primarily the result of banks' increased exposure to sovereign debt under AFS holdings, as a result of the tax reform. The effect is especially visible in the case of banks with the greatest exposure to sovereign bonds, those that are less capitalized, as well as those with weak financial performance. Our regression results are robust with respect to many variables, model specifications, or yield curve simulation methods. We also find that banks are not significantly hedged against the market shock, additionally proving that market risk is an important source of risk for the banking sector that heavily invests in sovereign debt.

Our results contribute significantly to regulatory and policy-making debates. First, regulatory organizations such as the Basel Committee of Banking Supervision (BCBS), the European Banking Authority (EBA), or the European Systemic Risk Board (ESRB) have been concerned with banks' bias toward sovereign debt and high exposure concentration (see, e.g., EBA 2013, 2014; ESRB 2015). Second, the role of the fair-value accounting and its potential consequences for the banking sector have been extensively debated since the 2008 global crisis, leaving many questions unanswered (see, e.g., Laux and Leuz 2010; Laux 2016). Additionally, the recent Basel III regulation (BCBS 2010, paragraphs 7–9) requiring banks to account for their unrealized profits/gains and, more importantly, losses incurred in the process of financial investment in the regulatory capital, has raised heated discussion on the interplay of accounting and regulation and its impact on bank behavior (BCBS 2016). Finally, the growing sovereign debt in the wake of the COVID-19 pandemic has brought back concerns about the euro-area sovereign–bank nexus—a major amplifier in the sovereign debt crisis in the euro zone (European Central Bank 2020). Our findings offer an important insight into the above discussion.

The paper is organized as follows: Section 2 presents our contribution to the academic literature. In Section 3, we introduce the concept of a bank levy. Section 4 describes our data, while Section 5 presents our empirical strategy. In Section 6 we discuss our findings, and in Section 7 the robustness analysis. Our concluding remarks are presented in Section 8.

2. Contribution to Literature

Our results are a significant contribution to the regulatory and academic discussion on the role of government securities in banks' operation and the associated risk. More specifically, we have expanded the current knowledge base in three areas.

First, we address recent regulatory concerns regarding banks' bias with respect to sovereign debt investments. For many years, liquidity and collateral reasons were considered main factors motivating banks to hold government securities. As government bonds have been shown to be extremely liquid (e.g., Holmström and Tirole 1993) and default free, banks have used them to manage their liquidity and use them as collateral for their daily operations (Holmström and Tirole 1993; Bolton and Jeanne 2011; Gennaioli, Martin, and Rossi 2018). This behavior was further promoted when, in 2014, the European Capital Directive imposed zero-capital weight on the debt of majority of advanced countries. Popov and van Horen (2013), Boner (2016), and Gennaioli, Martin, and Rossi (2018) document that preferential regulatory treatment of government securities has been an important factor driving banks' decisions in favor of government securities. However, recently, some academic evidence has been found to suggest that banks invest in government securities to benefit from higher yields during the crisis (Acharya and Steffen 2015; Drechsler et al. 2016) and to compensate for the low interest rate environment (Altavilla, Pagano, and Simonelli 2017; Molyneux et al. 2021). Additionally, Horváth, Huizinga, and Ioannidou (2015) argue that some macro and micro features might predetermine banks' features in some countries to invest in sovereign debt. Our study contributes to this debate by investigating the role of fiscal reform that allows banks to save on taxes, thereby incentivizing them to shift their business to tax-free trading. We also examine banks that are more likely to engage in such behavior, analyzing their ownership structure as well as liquidity and capital needs.

Second, we contribute to the discussion on the determinants of banks' accounting choices. The impact of accounting on banks' operation has been specifically raised by the recent financial crisis, when some academicians blamed accounting rules for banks' problems and the systemic effect of the crisis (American Bankers Association 2008; Wallison 2008a, 2008b; Whalen 2008, or Forbes 2009). The importance of fair-value accounting for bank business and the kind of risk it imposes, given recent regulatory changes, has become the subject of a lively debate. The academic studies document that banks use fair-value accounting to increase or smoothen their regulatory capital or earnings (Moyer 1990; Barth at al. 2017). Moreover, banks use fair-value accounting to increase their trading revenues, especially when interest rates are low (Borio, Gambacorta, and Hofmann 2017; Claessens, Coleman, and Donnelly 2018; Molyneux et al. 2021). Individual features of certain banks may differentiate these effects. For example, low-capitalization banks may prefer to be less exposed to fair-value accounting than those characterized with higher capitalization, especially if revaluation changes affect banks' capital (Iselin and Nicolletti 2017). However, some regulatory aspects may reduce banks' incentives to classify their investment at the fair value. For example, Fuster and Vickery (2018) and Kim, Kim, and Ryan (2019) document that the removal of the prudential filter in the United States, as a result of the temporary SFAS 115 recommendation to include the unrealized gains and losses into banks' regulatory capital, has resulted in the reclassification of AFS debt securities as HTM investment. In addition, Beatty, Chamberlain, and Magliolo (1995) and Kim, Kim, and Ryan (2019) find that banks also reduce the duration of securities at the fair value to diminish the regulatory effect on banks' capital. Furthermore, Argimón, Dietsch, and Estrada (2018) investigate the sample of European banks and conclude that banks hold less fair-value assets in countries that have not introduced prudential filters on their capital. In our study, we add to this literature while testing the determinants of banks' accounting choices, controlling not only for the role of the fiscal reform but also for macro and micro features of the banking environment in light of the recent regulatory changes that might determine banks' accounting choices.

Finally, our study contributes to the discussion on banks' risk associated with an increased investment in sovereign debt. Many academic studies predominantly analyze banks' risk from the perspective of correlation of creditworthiness between the sovereign and banks (Acharya, Dreschler, and Schnabl 2014; Gennaioli, Martin, and Rossi 2014; Sosa-Padilla 2018; Bocola, Borstein, and Dovis 2019). In our study we are more interested in the consequences of the market risk on banks' performance. The decision on how banks classify their financial asset is crucial for evaluating the risk of investment, as "mark-to-market" rule requires that banks account for the market change in banks' portfolio either in banks' earnings or in regulatory capital, depending on the accounting classification (BCBS 2010, paragraphs 7–9; EU Capital Requirements Directive (CDR)). The role of fair-value accounting on banks' earnings and capital volatility has been discussed in numerous papers that analyze mainly banks' active trading behavior (Barth, Landsman, and Wahlen 1995; Hodder, Hopkins, and Wahlen 2006; Greiner 2015; BCBS 2015; Kim, Kim, and Ryan 2019; Argimón, Dietsch, and Estrada 2018). However, according to our knowledge none of the studies look at the market risk related with banks' debt investment and its accounting classification.

3. Bank Levy Reform in Poland

Bank levies were introduced following the 2008 financial crisis to internalize the costs of bank distress and discourage banks from undertaking risky activities in the future. Recently, 21 of 28 European countries, including Austria, Belgium, Cyprus, France, Germany, the Netherlands, Latvia, Portugal, Romania, Slovakia, Sweden, the United Kingdom, Poland, and Hungary, decided to introduce this regulatory instrument, albeit with different taxation schemes. While the levy design remains subject to legislative debate and may vary among countries, an increasing number of countries, including the United States, are considering its introduction (International Monetary Fund 2010).

Poland is one of the countries that introduced the bank levy relatively late: it was announced in late 2015 and came into force on February 1, 2016. The new tax covers the majority of financial institutions operating in Poland, including domestic banks, foreign subsidiaries, insurance companies, leasing companies, and finance companies. It excludes cooperative banks and banks undergoing resolution. The latter reason precludes banks from paying the tax upon the Financial Supervision Authority (FSA) approval. The tax is collected on a monthly basis (starting in February 2016) and the tax rate is set at 0.0366 percent. It is calculated on the average volume of assets exceeding EUR 1 billion by the end of the month, reduced by the volume of government securities and banks' equity.

Consequently, Poland is an interesting case in terms of the bank levy design, as it has imposed the levy on the asset side of banks' balance sheet while exempting government securities. As a result, sovereign debt has received preferential treatment in banks' balance sheet and become an attractive investment opportunity for banks. At the same time, the government has retained a privileged source of funding.

4. Banks' Financial Assets

To determine how the banking tax has affected sovereign bank holdings and the consequent risk, we use a sample of all commercial Polish banks that have paid the banking tax at least once since its introduction. Sample banks hold approximately 72 percent of total assets of the Polish banking sector.[4] To compare periods prior to and after the banking tax introduction, we use quarterly banks' balance sheet data for the period between 2008:Q1 and 2017:Q4. Bank-specific variables are taken from supervisory reporting, while macrofinancial indicators are sourced from the Bloomberg database.

4.1 Sovereign Exposure and Their Accounting Treatment

The data include banks' financial asset investment by each bank operating in Poland in each quarter, classified according to types of financial assets, balance sheet volume, maturity, and type of accounting. Regarding the latter, the International Financial Reporting Standards (IFRS) require classifying financial assets into the following three categories: "*available for sale*" (AFS), "*held for trading*" (HFT), and "*held to maturity*" (HTM). The choice of classification depends on the banks' intention to manage their sovereign debt. HTM securities are debt securities that the bank intends—and

[4]Our sample includes all commercial banks that have paid banking tax at least once during previous quarters. Nevertheless, it excludes two commercial banks that have been waived from paying the levy upon the FSA's decision to consider them as undergoing resolution. We also exclude cooperative banks from our analysis; we argue that these banks' operations and balance sheets are distinct from those typical of commercial banks.

is able—to hold until their maturity. Therefore, HTM investments are recorded at the amortized historical cost in banks' balance sheet. HFT securities are trading securities held by banks as sources of short-term profit, which means that they are to be sold within the next term. The regulation clearly specifies that banks are to sell them within 90 days, or else a penalty shall be imposed (IFRS 9). However, AFS securities include financial assets other than those categorized as HFT or HTM, in the case of which the holding period is not specified. Therefore, they provide banks with a greater flexibility of use.

Importantly, the classification of investment has a significant impact on banks' performance. Both HFT and AFS must be priced at the fair value in banks' balance sheets. However, an important difference between these two classifications is the treatment of these securities because of market revaluation. Since 2014, Basel III provisions require banks to report temporary changes in fair value under AFS securities as a part of tier 1 regulatory capital. However, it is not the case of HFT securities. The latter affects only net income when profit/loss is realized, or if the loss is "*other than temporary*" (BCBS 2010, paragraphs 7–9). However, the market risk does not affect HTM securities that are intended to be held until maturity. Our data allow us to distinguish the portion and type of financial assets classified under each accounting category. We present it as a ratio to total assets of a bank. Table 1 presents summary statistics for financial assets and its classification in the balance sheet.

The data show that, on average, domestic sovereign debt accounts for approximately 12 percent of total assets of banks from our sample. We also notice a great variation in sovereign debt holdings ranging from 0 to 55 percent of total assets. However, the average share of sovereign debt holding in stated-owned banks amounts to 9 percent, with a maximum share exceeding slightly 30 percent.

Moreover, our data show that the mean percentage of financial assets in banks' total assets stands at 17.37 percent. This further indicates that over 90 percent of financial assets held by banks are government securities, as compared with the European average of 80 percent (Argimón, Dietsch, and Estrada 2018). Interestingly, data suggest that fair-value accounting plays a significant role in banks'

Table 1. Financial Asset Investment at Sample Banks

	N	Mean	Median	Min.	Max.	Std. Dev.	p25	p75
A. Financial Assets to Total Assets								
FA	727	17.37	15.7	0	93.03	11.58	9.8	22.12
GOV_SEC	727	12.37	11.32	0	55.81	9.78	4.5	17.45
NBP_BILLS	727	4.81	3.47	0	93.03	6.1	0.44	7.29
SOV_SEC	727	9.32	8.43	0	31.79	3.31	9.92	10.96
B. Government Securities to Total Assets								
HFT_SEC	727	1.37	0.34	0	13.39	2.3	0	1.71
AFS_SEC	727	10.01	9.42	0	55.81	8.7	3.08	14.44
HTM_SEC	727	0.97	0	0	12.36	2.42	0	0.2
HFT_AFS_SEC	727	11.39	10.55	0	55.81	9.29	4.09	15.95

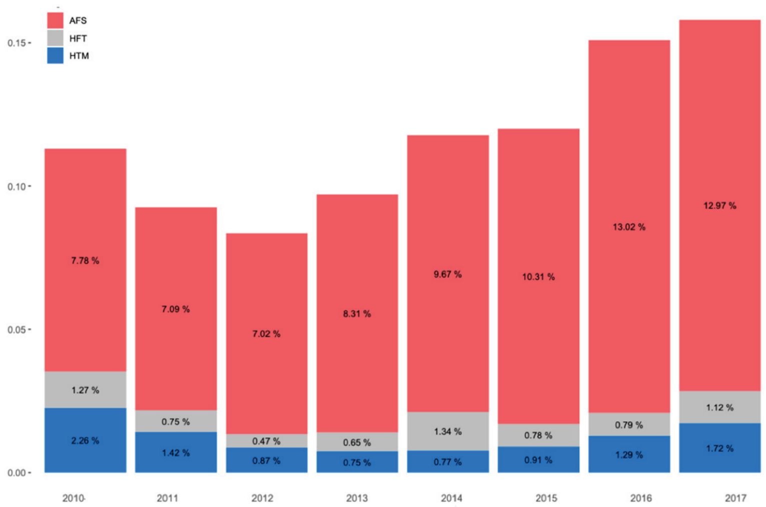
balance sheets. We notice that the highest share of financial investment has been classified under AFS, amounting on average to 14.42 percent. Remaining securities are negligibly split between HFT and HTM. Figure 2 shows the trend in Polish banks' classification of financial assets, the majority of which are government securities.

Notably, classifying debt as AFS securities has almost doubled since 2011. However, the largest increase occurred between 2015 and 2016, when the Polish regulator introduced fiscal incentives for banks investing in government securities, i.e., a tax on banking assets that excludes government bonds from the tax base. Results seem to suggest that fiscal incentives might have significantly affected banks' decisions to increase their government debt holding.

4.2 Understanding the SLIP Measure

To investigate the sensitivity of banks' portfolios to the yield curve shock, we employ a novel measure called the "shock-loss indicator of portfolio" (SLIP), which is a time-varying bank-level indicator based on stress-testing methodology measuring the sensitivity of the government bond portfolio of each sample bank to market movements during every quarter. More specifically, by using supervisory data on the duration and volume of banks' financial investment, and taking into account how banks classify their financial assets, we are able to calculate the sensitiveness of a portfolio to the yield curve shock.

Figure 2. Percentage Share of Financial Assets in Total Assets by Category



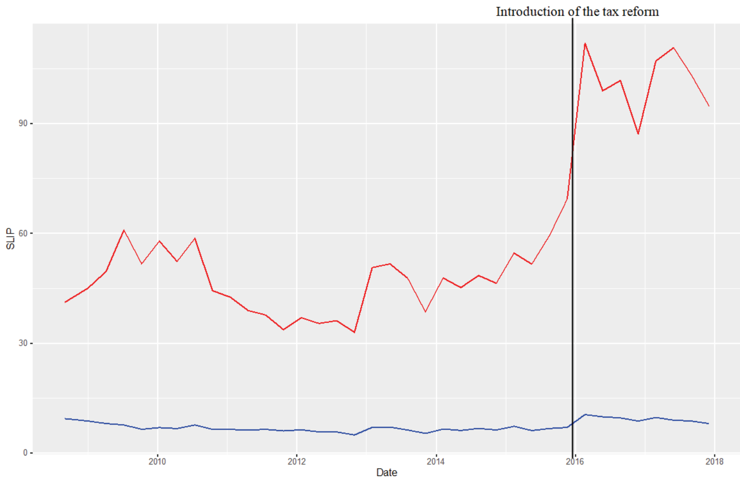
Source: National Bank of Poland (NBP).

Consequently, our SLIP measure is a function of a bank's total volume of interest rate sensitive government bonds recognized at fair value (HFT and AFS), their duration, and the yield curve shock. The SLIP has been calculated using the following equation:

$$\mathrm{SLIP}_{it} = \sum_{i,t}^{n} f\big(\mathrm{IRRSENSITIVEBSPOSITION}_{it};\ \mathrm{DURATION}_{it};\mathrm{IRRSHOCK}_{t}\big), \tag{1}$$

where SLIP_{it} represents a change in the price of the fair value of the government bond portfolio of bank i at time t, given the value of the debt asset ($\mathrm{IRRSENSITIVEBSPOSITION}_{it}$), its duration over different periods ($\mathrm{DURATION}_{it}$), and an increase in yield curve ($\mathrm{IRRSHOCK}_{t}$). We standardize SLIP by dividing it by the annual financial result (defined as net income) and banks' tier 1 capital to examine the economic impact of the revaluation at a bank level.

Figure 3. SLIP Measures



Source: Own estimations.
Note: The shock-loss indicator of portfolio (SLIP) is defined as a loss in government securities value as a result of a 300 bp upward change in the yield curve, and it is stated as a ratio of a bank's capital funds (blue line) and net income (red line).

Consequently, SLIP allows us to test how the valuation of banks' portfolios changes depending on the yield curve shock. In our baseline assumption, we consider a 300 bp upward yield curve shift. Such an increase is highly probable, for example, due to a spike in the credit risk of a sovereign, as the European sovereign crisis has proven (Kirschenmann, Korte, and Steffen 2020). In our later analysis, we also provide evidence that banks' exposure to interest rate risk arising from the portfolio of Treasury securities is mostly unhedged by derivatives, such as interest rate swaps (IRS). In addition, in the robustness check, we also consider a non-linear shock to the bond-yield curve as an alternative to the 300 bp parallel shift. Figure 3 presents the SLIP measure over time, aggregated at all sample banks in two variations: in relation to banks' tier 1 capital and to banks' earnings.

Data clearly show that prior to the tax reform, banks were less exposed to changes in the yield curve due to a lower proportion of assets being exposed to market movements. As a result of an increased demand for government securities, banks are more exposed to risks related to market movements, which has consequently increased the volatility of their capital and profits. Figure 3 shows that, at the end of 2017, a 300 bp increase in the yield curve would have caused, on average, a drop in the bank's capital by around 8 percent, and in its profits by more than 100 percent. This result unambiguously evidences that banks' investment classified at fair value, and more specifically at AFS holdings, exposes banks to a greater market risk. Consequently, in a situation of a market shock, an increase in government bond yields may lead to the insolvency of some banks, and impair financial-sector stability.

5. Empirical Strategy

To address our research questions, we conducted three arrays of analyses. First, we investigated the motivation of banks to hold domestic sovereign debt given the recently introduced fiscal reform. Second, we explored banks' accounting choices, including the impact of the fiscal factor on these decisions. Finally, we examined whether (and, if so, how) an increased sovereign debt holding increases banks' exposure to the market risk.

We estimated all our regression models using the generalized least squares (GLS) method with random effects. The choice of the estimator was dictated by the result of the Hausman test.[5] Moreover, as some of our regressors are characterized by slow time variation—e.g., banks' ownership structure—fixed-effect regressions might lead to inflated standard errors. This is another argument for the use of the random-effects model, which ensures that time-invariant bank effects are unlikely to be correlated with our main regressors. The random-effects model has been also shown to be more effective in this context than the fixed-effects model or the pooled ordinary least squares (OLS) regression (see Wooldridge 2013, chapter 10).

[5]The Hausman test is used to verify whether a difference in coefficients is not systemic (H0). The fixed-effects model should be used when the p-value is lower than 0.05. Prob>chi2 for our baseline model for government bonds equals 0.2042, suggesting that, in our analysis, the random-effects model is preferable to the fixed-effects model.

5.1 Do Banks React to Fiscal Incentives to Hold Sovereign Debt?

We examine the determinants of domestic sovereign bank holdings in two ways. First, we analyze how fiscal incentives affect banks' demand for financial assets, with emphasis on tax-exempt sovereign bonds. Second, we explore the link between banks' financial investment and accounting choices. More specifically, we determine micro and macro factors, including fiscal incentives, which might affect banks' decision to classify their financial investment into specific accounting groups. We argue that the drive for a better performance might motivate banks to hold more tax-exempt sovereign bonds. In addition, we posit that in the diminishing interest rate environment, banks prefer to classify their financial investments at fair value, as monetary policy easing might encourage them to engage in trading activity to offset low interest income (Molyneux et al. 2021). Consequently, we argue that in an environment of decreasing interest rates, banks prefer to classify their investment into the AFS portfolio, as it provides them with a greater flexibility in terms of risk management and it creates a possibility of financially profiting from such holdings either in terms of additional capital buffers or capital gains.

Model specifications capture the effect of the new fiscal regulation on the composition of financial instruments in banks' balance sheets and their accounting classification. The following equation shows the baseline model:

$$\mathrm{DEP}_{it} = f\,(\mathrm{TAX}_{it}; \mathrm{MACRO}_{t}; \mathrm{BANK}_{it}), \tag{2}$$

where DEP_{it} represents endogenous variables measured at quarter t for bank i. DEP contains the following outcome variables: (i) financial assets (FA), (ii) Treasury securities (GOV_SEC), (iii) central bank bills (NBP_BILLS) and their accounting classification such as HTM_SEC, HFT_SEC, and AFS_SEC. We scale the balance sheet volumes by dividing them by the bank's total assets. Our main regressor is the banking tax (TAX_DUMMY), a binary variable that takes the value of 1 if a bank i pays taxes during period t. In the robustness section, we also employ the tax ratio (TAX_RATIO) instead of a dummy variable, which we define as the amount of levy paid by each bank in relation to its bank's total assets. MACRO is a vector of macro-wide control variables and BANK is a vector of bank-specific characteristics, as discussed below.

5.2 What Is the Risk Associated with Banks' Increased Investment in Sovereign Debt?

In our study, we are particularly interested in banks' risk related to an increased investment in sovereign debt. We argue that this risk might be due to the revaluation of banks' portfolio because of the yield curve shock and fair-value accounting. The latter requires banks to reevaluate their investment according to current prices and to include the changes in banks' earnings or regulatory capital, depending on whether banks classify such investment as HFT or AFS. To evaluate how banks' earnings and regulatory capital become volatile, as a result of banks' increased investment in sovereign debt, we regress the following model:

$$\mathrm{DEP}_{it} = f\,(\mathrm{TAX}_{it}; \mathrm{MACRO}_{t}; \mathrm{BANK}_{it}), \tag{3}$$

where DEP_{it} is a SLIP_{it} indicator that represents the change in debt revaluation in relation to banks' tier 1 capital ratio and net income for bank i and quarter t as a result of a yield curve shock of 300 bp. As banks' increased investment in sovereign debt might also increase the duration of banks' assets, we alternatively use the DURATION variable (the subcomponent of SLIP) as a proxy of banks' risk. Our main regressor is the banking tax (TAX_DUMMY), a binary variable that takes the value of 1 if a bank i pays taxes during period t. MACRO is a vector of macro-wide control variables and BANK is a vector of bank-specific characteristics, as discussed below.

5.3 Control Variables

We introduce a set of macroeconomic and bank-specific control variables into our analysis. First, we add the ratio of net loans to total assets as a measure of bank activity (CREDIT). We expect a negative relationship with our endogenous variable, as banks might substitute government securities by reducing their loan activity (Gennaioli, Martin, and Rossi 2018). We also control for bank size using the log of total assets (LNTA). We expect larger banks to hold greater financial assets because of their larger trading portfolios

(Ogawa and Imai 2014; Gennaioli, Martin, and Rossi 2018). We also control for banks' specific features, such as liquidity position, defined as the ratio of deposits to banks' total assets (DEPOSIT), as well as banks' capital ratio, measured as tier 1 capital to risk-weighted assets (RWA) (CET1). A higher share of deposits in banks' balance sheets is expected to reduce banks' purchases of sovereign bonds (Bouis 2019). According to the recent studies, undercapitalized banks purchased domestic government bonds to make profit (Acharya and Steffen 2015), shift risk (Drechsler et al. 2016), or obtain central bank liquidity during the crisis (Crosignani, Faria-e-Castro, and Fonseca 2020). Therefore, we assume a negative correlation between the capital adequacy ratio and government holdings of a bank. We also control for banks' profitability measures such as return on assets (ROA). More profitable banks might have a higher percentage of financial assets in their balance sheet, as they try to compensate for the low interest rate environment with additional trading income (Borio, Gambacorta, and Hofmann 2017; Claessens, Coleman, and Donnelly 2018; Molyneux et al. 2021). Finally, we also control for the type of ownership, taking into account whether a bank is state owned. Horváth, Huizinga, and Ioannidou (2015) and DeMarco and Macchiavelli (2016) document that politically connected banks tend to hold more government debt.

Regarding macro variables, we control for the Warsaw interbank offered rate (WIBOR), which is an interbank rate at which funding can be purchased on the interbank market. We expect that in a diminishing interest rate environment banks may substitute loans by financial securities to profit from capital gains (Acharya and Steffen 2015). Buch, Koetter, and Ohls (2016) find that macroeconomic fundamentals might become significant drivers of sovereign bond holdings, especially during a contraction period, when the "flight to quality" becomes evident. However, Acharya and Steffen (2015) and Gennaioli, Martin, and Rossi (2018) document that banks prefer to invest in sovereign debt during default times, searching for higher yields. Therefore, we also include GDP, debt-to-GDP (DEBT), and five-year credit default spread (CDS) to control for the economic situation in a country and the consequent country credit risk.

Summary statistics on the variables and the correlation matrix used in our regression analyses are presented in Tables 2 and 3, respectively.

Table 2. Descriptive Statistics for Data Used in the Study

	N	Mean	Median	Min.	Max.	Std. Dev.	p25	p75
A. Explanatory Variables								
TAX_DUMMY	727	0.2	0	0	1	0.4	0	0
TAX_RATIO	727	0.01	0	0	0.08	0.02	0	0
SIZE(LN)	727	10.18	10.5	4.97	12.54	1.39	9.35	11.13
CREDIT	727	70.3	73.07	0.04	110.41	18.24	61.01	81.54
DEPOSITS	723	54.12	61.57	0	84.34	21.74	44.05	69.33
NPL	714	7.91	6.95	0	100	7.41	4.59	9.12
CET1	727	16.56	12.27	5.68	822.02	35.3	10.74	15.43
ROA	667	0.71	0.92	−24.69	6.11	2.34	0.43	1.38
WIBOR	727	3.42	3.78	1.67	6.52	1.5	1.73	4.57
GDP	727	3.34	3.49	0.11	5.93	1.35	2.57	4.13
DEBT	727	51.49	52.44	42.36	56.56	3.48	49.5	53.84
CDS	727	106.32	78.39	43.5	314.4	65.7	63.82	135.1
SOV	727	0.14	0	0	1	0.35	0	0
B. SLIP Variables								
SLIP_FUND	680	7.57	4.93	0	66.98	8.51	0.87	11.65
SLIP_PROFIT	627	109.82	39.48	−1,620.79	3,449.73	371.51	7.48	93.07
DURATION	712	1.44	1.28	0.01	7.5	1.23	0.37	2.12

Table 3. Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1) FA	1.000																		
(2) GOV_SEC	0.853	1.000																	
(3) NBP_BILLS	0.262	–0.165	1.000																
(4) TAX_DUMMY	0.077	0.229	–0.231	1.000															
(5) TAX_RATIO	0.056	0.195	–0.215	0.958	1.000														
(6) SIZE(LN)	0.104	0.223	–0.105	0.188	0.248	1.000													
(7) CREDIT	–0.836	–0.768	–0.222	0.043	0.033	–0.112	1.000												
(8) DEPOSITS	0.286	0.329	0.009	0.122	0.137	0.478	–0.259	1.000											
(9) NPL	–0.146	–0.176	0.102	–0.073	–0.077	–0.049	0.188	0.002	1.000										
(10) CET1	0.350	0.065	0.491	–0.023	–0.019	–0.281	–0.318	–0.216	–0.104	1.000									
(11) ROA	–0.156	–0.112	–0.033	0.024	0.027	0.346	0.155	0.013	0.165	–0.199	1.000								
(12) SOV	0.076	0.031	–0.002	0.107	0.093	0.018	0.008	0.227	–0.016	0.075	0.037	1.000							
(13) WIBOR	–0.081	–0.077	–0.055	–0.565	–0.541	–0.251	–0.089	–0.152	0.092	–0.005	–0.050	–0.090	1.000						
(14) GDP	0.008	0.073	–0.130	0.178	0.184	–0.030	–0.003	–0.002	0.020	0.003	–0.111	0.041	–0.059	1.000					
(15) DEBT	0.014	–0.057	0.178	0.183	0.180	0.133	0.143	0.137	–0.048	–0.053	0.014	0.018	–0.399	–0.292	1.000				
(16) CDS	0.009	0.026	–0.037	–0.309	–0.300	–0.172	–0.062	–0.114	–0.037	–0.003	–0.043	–0.054	0.561	–0.052	0.002	1.000			
(17) SLIP_FUND	0.579	0.707	–0.215	0.111	0.075	0.212	–0.524	0.273	–0.043	–0.044	0.116	0.011	0.019	0.059	–0.106	–0.029	1.000		
(18) SLIP_PROFIT	0.095	0.155	–0.011	0.148	0.121	0.032	–0.018	0.123	0.046	–0.046	–0.013	0.043	–0.131	0.037	0.004	–0.076	0.292	1.000	
(19) DURATION	0.263	0.340	–0.230	0.094	0.086	0.166	–0.250	0.217	–0.123	–0.017	0.154	–0.042	–0.033	–0.046	0.042	–0.086	0.641	0.240	1.000

Table A.1 in the appendix presents the definition of all variables used in our analyses.

6. Results

This section presents regression results for our three main research questions.

6.1 Do Banks React to Fiscal Incentives to Hold Sovereign Debt?

In line with our hypothesis, we check whether and how fiscal incentives offered to banks to exclude sovereign debt from tax have increased the demand for these securities and consequently motivated banks to shift their investment into this class of assets. In line with recent evidence provided by Popov and van Horen (2013), Boner (2016), and Gennaioli, Martin, and Rossi (2018), banks are prone to increasing their government securities holding if they are offered incentives to do so. In addition, in line with other scholars, we are interested in whether banks' size and ownership structure affect the decision to increase the sovereign debt portfolio in the balance sheet.

Table 4 presents our estimations: we analyze the effect of the fiscal reform and banks' demand for financial assets in general (Specification (1)), and specifically with respect to sovereign debt (Specification (3)). We might also expect that a greater demand for sovereign debt might cause a drop in demand for assets other than government securities, as banks might replace them with tax-exempted securities. Apart from sovereign bonds, Polish banks mainly hold NBP bills in their financial portfolios; therefore, we look at how a potentially increased demand for government securities has changed the demand for NBP bills. We present these regression results in Specification (2). In addition, we also present regression results testing additional banks' features, which could explain the differential impact of levy on banks' holdings of government debt, by introducing interaction variables between the tax dummy and the bank's ownership structure—SOV_TAX (Specification (4)) or the bank's size—SIZE_TAX (Specification (5)). Consequently, we would verify how certain characteristics, such as the size and the

Table 4. Bank Behavior to Preferential Treatment of Sovereign Debt Securities

	FA (1)	**NBP_BILLS (2)**	**GOV_SEC (3)**	**GOV_SEC (4)**	**GOV_SEC (5)**
TAX_DUMMY	1.890**	–4.545***	6.338***	7.034***	20.390***
	(0.858)	(0.781)	(1.015)	(1.157)	(7.657)
SIZE(LN)	–0.108	–0.022	–0.426	–0.407	–0.276
	(0.689)	(0.719)	(0.924)	(0.905)	(0.882)
CREDIT	–0.454***	–0.189***	–0.302***	–0.301***	–0.299***
	(0.083)	(0.048)	(0.067)	(0.068)	(0.064)
DEPOSITS	0.125**	–0.008	0.092*	0.080	0.095*
	(0.062)	(0.042)	(0.052)	(0.051)	(0.051)
NPL	0.153	0.192***	0.069	0.091	0.074
	(0.117)	(0.073)	(0.129)	(0.124)	(0.131)
CET1	0.091	–0.096**	0.017	0.010	0.034
	(0.110)	(0.049)	(0.072)	(0.072)	(0.071)
ROA	–0.383***	0.0573	–0.260	–0.287	–0.278
	(0.144)	(0.120)	(0.232)	(0.226)	(0.232)
SOV	–1.901*	2.803**	–3.631*	–0.498	–3.269
	(1.134)	(1.327)	(1.991)	(1.483)	(2.001)
WIBOR	0.109	0.044	–0.023	–0.030	–0.003
	(0.339)	(0.262)	(0.394)	(0.391)	(0.394)
GDP	0.289	0.042	0.290**	0.299**	0.286**
	(0.194)	(0.129)	(0.120)	(0.118)	(0.123)
DEBT	0.0307	0.339***	–0.211**	–0.208**	–0.216**
	(0.133)	(0.109)	(0.103)	(0.101)	(0.102)
CDS	–0.008*	–0.014***	0.004	0.004	0.005
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
SOV_TAX				–4.568***	
				(1.488)	
SIZE_TAX					–1.318*
					(0.720)
Constant	39.52***	3.175	41.30***	41.21***	39.17***
	(10.17)	(9.527)	(12.33)	(12.140)	(11.990)
No. of Obs.	662	662	662	662	662
R2	0.734	0.128	0.665	0.678	0.683

Note: The table presents the results of the GLS model with random effects and standard errors clustered at the bank level. The sample consists of all Polish commercial banks which paid the bank tax. The sample period is from 2008:Q1 to 2017:Q4. TAX_DUMMY is a binary variable which equals 1 for all the periods tax is due; 0 otherwise. Financial asset is as a ratio to total assets; the variable GOV_SEC is defined as a ratio of government securities to total assets; NBP_BILLS is defined as a ratio of National Bank of Poland bills to total assets. SOV is a dummy equal to 1 if a bank is controlled by the state; 0 otherwise. The variables SIZE_TAX and SOV_TAX are defined as an interaction of a bank's size (ln) and state-owned dummy with the tax dummy variable, respectively. ***, **, and * stand for statistical significance at the 1 percent, 5 percent, and 10 percent significance level, respectively.

ownership structure of the bank, influence its decision to increase its sovereign debt holdings following the introduction of the reform.

Our estimations from Table 4 evidence that fiscal incentives offered to banks have increased banks' demand for sovereign debt. Regression coefficients in Specifications (1) and (3) are statistically significant and positive. Results confirm the hypothesis that the fiscal motive, allowing banks to save on taxes, significantly increases the demand on investment in sovereign debt. This finding is in line with studies proving that preferential treatment induced by regulatory authorities to promote government securities in banks' balance sheet seems to be extremely successful (Popov and van Horen 2013; Boner 2016). At the same time, we also document that banks decreased NBP bills holdings, which were not exempted from the banking tax, confirming also the substitution effect between NBP bills and Treasury securities (Specification (2)).

Interestingly, the comparison between coefficients in our three specifications (1)–(3) suggests that the increase in sovereign debt holding was higher than the drop in NBP bills. More specifically, the estimation of Specification (1) indicates that the ratio of financial assets in banks' total assets has increased by 1.890 percentage points, suggesting that the demand effect exceeded NBP bills reduction (Specification (2)). While the decrease in the ratio of NBP bills to assets accounts for 4.545 percentage points, the increase in government securities stands at 6.338 percentage points (Specification (3)), which is almost 1.890 percentage points above the decrease value. Consequently, our findings show that fiscal incentives offered to banks have induced additional demand for sovereign debt and, at the same time, led to a decrease in other types of financial assets, including credit, as we also document in a subsequent part of our paper.

Additional estimations document that the attitude toward government debt investment seems to be heterogeneous between different bank types. Interestingly, the coefficient of SOV seems to indicate that stated-owned banks hold less sovereign debt than private banks (Specifications (1), (2), and (3)). In addition, we notice that the interaction variable of banks' state ownership, SOV_TAX, is highly statistically significant and negative (Specification (4)), which suggests that stated-owned banks hold 4.5 times fewer government bonds than private banks after the introduction of the reform. The result indicates that the demand for government bonds has been mainly driven by private banks.

Recent academic studies argue that private banks tend to hold more sovereign debt to increase the bailout probability (Acharya and Steffen 2015). We, however, argue that in the case of Poland, a more probable explanation is that state-owned banks are politically pressured to realize their social mission, and thus continue lending to the economy. In turn, private banks are more result oriented and, consequently, more interested in minimizing the tax burden by increasing its portfolio of tax-exempted products. This is in line with some studies, e.g., Kahan and Rock (2011) or Yang (2019). Our findings on ownership are also supported by the effect on the size interaction variable (Specification (5)). The interaction variable coefficient shows the negative sign, suggesting that smaller banks invested 1.3 times more in government securities after the reform than larger banks. At the same time, we also notice that the effect of TAX becomes even more economically significant while controlling for this interaction term, suggesting that the levy reform has induced the demand for government securities mainly by smaller banks. Given that the largest Polish banks are state owned, the result is consistent with our ownership evidence that smaller private banks tend to hold more domestic debt than large state-owned banks.

Our regression results hold even when we control for other potential effects. We notice that the majority of other banks' financial features, potentially important for sovereign debt holding, appear as statistically insignificant or barely significant. This suggests that banks' decisions on sovereign debt holding have been mainly financially driven and not determined by any specific banks' needs, such as liquidity or capital. The only statistical impact on banks' debt holding we have found regarded CREDIT and DEPOSITS variables. The result supports our previous premises and other academic studies suggesting that banks replace their lending activity with investment in government securities (Gennaioli, Martin, and Rossi 2018). The positive coefficient sign of DEPOSITS suggests that a higher deposit ratio promotes banks' investment in sovereign debt.

Interestingly, regression results from Table 4 suggest that macroeconomic variables tend to play a more important role in our regressions than individual banks' characteristics. We find that positive

GDP growth increases the demand for government securities. Moreover, we notice that the country's higher debt negatively affects the demand for sovereign debt (Specification (3)). In such situations, banks tend to shift their investment into NBP bills (Specification (2)), while reducing sovereign debt exposure. This effect might suggest that a greater sovereign risk might discourage banks from investing in long-term government securities due to potentially negative consequences of this investment on banks' regulatory ratios. As a result, banks decide to replace these securities with risk-free short-term central bank bills. Logically, we have noticed that a higher five-year CDS, and thus a greater degree of risk, discourages banks from investing in sovereign debt.

6.2 Determinants of Banks' Accounting Choices

According to IFRS, banks must classify their financial investment into three categories—HTM, HFT, or AFS—depending on their trading intention. It is, however, not entirely clear which factors affect banks' decisions. In this section, we shall verify how micro and macro factors, and more specifically tax reforms, determine how banks classify their investment. We would expect fair-value accounting to be more likely if it can positively affect or improve banks' performance. This is particularly visible in an environment of low interest rates or during turbulent times when banks could benefit from higher yields (Acharya and Steffen 2015; Fuster and Vickery 2018; Molyneux et al. 2021). However, banks are more reluctant to include investment under fair-value accounting if it might negatively affect regulatory measures (Danmarks NationalBank 2015). Consequently, the effect of the bank levy on banks' accounting classification of sovereign securities remains uncertain, especially since 2014, as banks have been required to immediately account for any unrealized changes in the portfolio value. On the one hand, banks might want to include their debt investment under the AFS classification because of the flexibility of the investment and potential performance benefits. On the other hand, they might be discouraged because of the risk of increasing the volatility of their regulatory capital. Table 5 presents regression results while considering the proportion of banks' government securities under each accounting classification specified as HTM, HFT, AFS, and the sum of investment under HFT and AFS, respectively.

Table 5. Bank Behavior to Preferential Treatment of Sovereign Debt Securities

	HFT_SEC (1)	AFS_SEC (2)	HTM_SEC (3)	HFT_AFS_SEC (4)
TAX_DUMMY	–0.357	6.622***	0.181	6.244***
	(0.372)	(1.347)	(0.459)	(1.111)
SIZE(LN)	0.0424	–0.270	–0.429	–0.262
	(0.326)	(0.947)	(0.556)	(0.902)
CREDIT	–0.0434*	–0.220***	–0.0234	–0.261***
	(0.024)	(0.073)	(0.047)	(0.068)
DEPOSITS	–0.0158	0.109**	0.00679	0.0939**
	(0.0154)	(0.0468)	(0.0233)	(0.0459)
NPL	0.0215	0.0848	–0.0228	0.109
	(0.041)	(0.127)	(0.078)	(0.135)
CET1	–0.0286	0.0874	–0.0398	0.0587
	(0.023)	(0.083)	(0.046)	(0.078)
ROA	0.0690	–0.469**	0.134	–0.397*
	(0.0696)	(0.236)	(0.114)	(0.212)
SOV	0.509	–5.795***	0.727	–5.338***
	(0.382)	(2.023)	(0.470)	(1.799)
WIBOR	0.0747	–0.349	0.181	–0.269
	(0.112)	(0.372)	(0.114)	(0.409)
GDP	–0.0220	0.0848	0.193**	0.0745
	(0.0777)	(0.0879)	(0.0958)	(0.139)
DEBT	–0.0799	–0.134	–0.0114	–0.216**
	(0.0579)	(0.0929)	(0.0494)	(0.105)
CDS	0.001	0.004	0.0005	0.004
	(0.001)	(0.003)	(0.001)	(0.003)
Constant	8.902	27.77**	6.484	36.92***
	5.655)	(13.30)	(9.452)	(13.02)
No. of Obs.	662	662	662	662
R2	0.630	0.464	0.169	0.550

Note: The table presents the results of the GLS model with random effects and standard errors clustered at the bank level. The sample consists of all Polish commercial banks which paid the bank tax. The sample period is from 2008:Q1 to 2017:Q4. TAX_DUMMY is a binary variable which equals 1 for all the periods tax is due; 0 otherwise. Government securities is defined as a ratio to total assets held under specific IFRS classification at banks' balance sheet: held to maturity (HTM_SEC), available for sale (AFS_SEC), held for trading (HFT_SEC). HFT_AFS_SEC is a sum of HFT and AFS holdings in relation to total assets. ***, **, and * stand for statistical significance at the 1 percent, 5 percent, and 10 percent significance level, respectively.

Our estimation results document a significant effect of fiscal incentives offered to banks, and a link with fair-value accounting. At the same time, controlling for other factors, we notice a statistically positive effect of the tax reform on AFS classification. We have not found any significant effect of the banking tax reform on other classes of assets—neither on HTM nor on HFT—suggesting that fiscal incentives have specifically increased banks' interest in AFS investment. The result in Specification (2) evidences that the tax reform has increased the volume of government securities accounted as AFS more than six times. If we look at the result from Specification (4), while aggregating HFT and AFS banks' holdings, it seems that the increase can be accounted for by the new demand for government securities. The coefficient of a tax dummy on HFT_AFS_SEC is only slightly lower than that of AFS holdings (Specification (2)). In other words, the result seems to suggest that banks presumably reclassify some securities from HFT into AFS; however, this movement is almost insignificant as compared with the new AFS investment. The regression results show that the majority of AFS holdings come from an additional increase in sovereign debt induced by the tax reform. Interestingly, we do not see any other motives of banks' increased holdings of government debt, such as changes in the risk-free rate (WIBOR) or sovereign risk premium (CDS), again suggesting that an increased demand for government securities has been mainly induced by the tax reform.

One possible explanation for banks opting for the AFS portfolio is the flexibility of this investment. First, banks may be reluctant to maintain significant trading portfolios under HFT due to their traditional business model, an excessive volatility in earnings, or capital requirements higher than the market risk (BCBS 2022). Second, banks might avoid classifying assets in HTM because of their commitment to low-earning assets in an environment of potentially rising rates, loss of potential capital gains, or liquidity issues, especially given the long duration of securities. Considering these two arguments, AFS accounting allows banks to sell off assets to address liquidity problems at any time and without incurring any "accounting penalties"[6]; in addition, it does not entail any increase in capital

[6]If an institution changes its intention, or can no longer hold even a single security up to its contractual maturity, generally the entire portfolio is "tainted"

requirements related to the trading book. In the context of the fiscal reform, AFS flexibility might have constituted an additional advantage taking into account uncertainty regarding the broader effects and sustainability of the new regulation. Consequently, our findings prove that the tax reform has intensified banks' investment in AFS holdings.

6.3 How Does an Increase in Sovereign Debt Holding Expose Banks to Market Risk?

Holding financial assets under AFS investment exposes banks to higher revaluation risk, as IFRS requires to "mark-to-market" such securities, simultaneously making banks' regulatory measures more volatile (Iselin and Nicolletti 2017; Argimón, Dietsch, and Estrada 2018; Jobst and Oura 2019). According to the recent change in Basel III, the unrealized profits and losses as a result of market revaluation must be included in banks' regulatory capital (BCBS 2010, paragraphs 7–9). In this section, we investigate the sensitiveness of sovereign debt investment, with the tax dummy as a proxy, toward the market risk, and we test the impact of sovereign debt revaluation—as a result of an increase in the yield curve by 300 bp—on banks' performance volatility. We present revaluation losses in terms of banks' earnings and capital. In addition, we check the effect of sovereign debt on banks' asset duration in line with the hypothesis that it is not only banks' investment in sovereign debt but also a greater duration of their investment that exposes banks to market risks. Table 6 presents regression results on the SLIP measure described in Section 4.

The results in Table 6 show that fiscal incentives increase the SLIP measure, and thus also the market risk. More specifically, we find that the TAX_DUMMY variable is statistically significant (at the 1 percent significance level) for both SLIP_FUND and SLIP_PROFIT variables. This means that fiscal incentives offered to banks, and consequently increased banks' investment in sovereign debt, have exposed banks to a higher market risk. Banks' risk

and must be reclassified as AFS, which might generate significant losses for the bank.

Table 6. Shock-Loss Indicator of Portfolio and Duration of Government Securities

	SLIP_FUND (1)	**SLIP_PROFIT (2)**	**DURATION (3)**
TAX_DUMMY	3.562***	112.3***	0.233
	(1.036)	(33.97)	(0.223)
SIZE(LN)	–1.122	23.47	–0.194
	(0.966)	(64.58)	(0.234)
CREDIT	–0.261***	–0.686	–0.015
	(0.079)	(3.491)	(0.012)
DEPOSITS	0.050	–0.792	0.008
	(0.046)	(1.085)	(0.006)
NPL	0.155	9.459	–0.009
	(0.223)	(7.663)	(0.016)
CET1	–0.304**	–3.353	–0.002
	(0.136)	(4.057)	(0.010)
ROA	0.225	–11.46	0.097*
	(0.214)	(20.15)	(0.052)
SOV	2.612	–49.09	0.886
	(2.071)	(100.8)	(0.742)
WIBOR	–0.350	–28.75	–0.017
	(0.507)	(25.03)	(0.093)
GDP	–0.075	–2.614	–0.072
	(0.234)	(4.445)	(0.063)
DEBT	–0.005	–0.754	0.044**
	(0.114)	(1.734)	(0.020)
CDS	0.003	0.240	–0.001
	(0.006)	(0.362)	(0.001)
Constant	37.16**	30.16	1.917
	(15.92)	(828.6)	(3.156)
No. of Obs.	662	662	653
R2	0.490	0.0175	0.0344

Note: The table presents the results of the GLS model with random effects and standard errors clustered at the bank level. The sample consists of all Polish commercial banks which paid the bank tax. The sample period is from 2008:Q1 to 2017:Q4. TAX_DUMMY is a binary variable which equals 1 for all the periods tax is due; 0 otherwise. The shock-loss indicator of portfolio (SLIP) is defined as a loss in government securities value as a result of a 300 bp upward change in the yield curve, and it is stated as a ratio of a bank's capital funds (SLIP_FUND) and net profits (SLIP_PROFIT). DURATION is defined as weighted average time until all payments from government debt held under AFS and HFT are settled. ***, **, and * stand for statistical significance at the 1 percent, 5 percent, and 10 percent significance level, respectively.

(measured by SLIP) increased by an average of 3.5 percent in relation to their own funds, and by an average of approximately 112 percent in relation to banks' profits. In other words, this potential loss can be accounted for by the introduction of the fiscal reform measured as a change in banks' portfolio revaluation following an increase in the yield curve by 300 bp. This significant difference in losses in relation to banks' capital and profits is the result of disparities in terms of the financial performance of banks. In addition, our regression results seem to suggest that the effect comes from an increased investment of sovereign debt rather than an extension of the duration of banks' portfolios (Specification (3)). This is in line with other studies documenting that banks seem to make the changes within their portfolios without extending their duration (Chirchop and Novotny-Farkas 2016; Kim, Kim, and Ryan 2019).

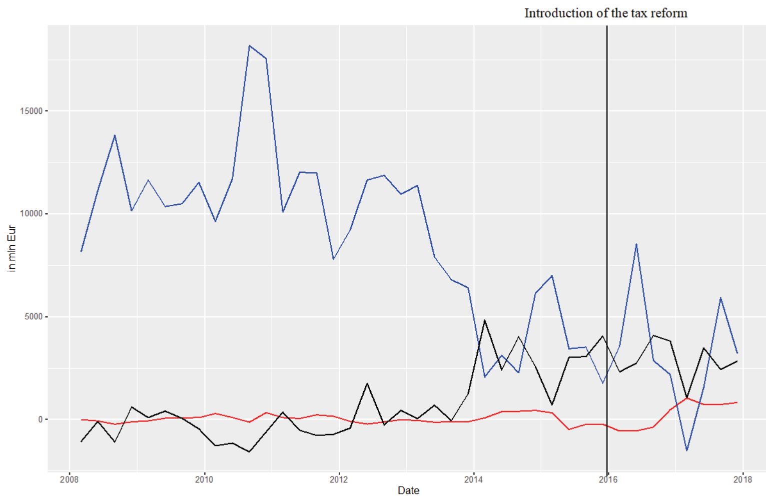
Consequently, increased investment in government securities at the fair value significantly increases the volatility of banks' regulatory measures. Such a massive revaluation loss might, first of all, have an impact on the bank's ability to meet capital requirements and, secondly, negatively affect the stability of the banking sector. Our estimations confirm the findings of studies that point toward an increased risk stemming from excessive investment in government bonds. However, unlike other studies, our analysis has proven that the risk comes from the market and banks' decisions on accounting classification of their debt.

Results regarding other control variables suggest that less-capitalized banks and banks with a high sovereign exposure in relation to their assets are more exposed to market risk (Specification (1)). The latter effect is suggested by the negative impact of CREDIT on the SLIP_FUND, indicating that a lower loan ratio exposes banks to a greater market risk due to a higher proportion of sovereign debt in banks' assets.

6.4 Are Banks Hedged against the Market Risk?

One can argue that the loss generated by an interest rate shock might be less significant, as banks try to protect their portfolio by hedging against adverse shocks. However, even if this is the case, recent estimations show that banks are not perfectly hedged (Gomez et al. 2016). For example, Hoffmann et al. (2018) document that

Figure 4. Index for Hedging from 2008:Q1 to 2017:Q4



Source: Supervisory data.
Note: The figure illustrates the interest rate gap defined as a difference between interest-bearing zloty off-balance-sheet assets and liabilities in a given period range to the repricing date; the repricing profile of off-balance-sheet interest-rate-sensitive assets and liabilities indicates that the net position is minor and positive for all repricing periods. Long position in off-balance-sheet items proves that banks do not hedge their long on-balance-sheet position in debt instruments (to 1Y: blue; from 1Y: red; from 1Y to 5Y: black).

hedging eliminates only around 25 percent of on-balance-sheet exposure, which means that banks remain exposed to interest rate risk (IRR) also after hedging. However, Begenau, Piazzesi, and Schneider (2015) document that the majority of U.S. banks do not use interest rate derivatives.

In our robustness analysis, we show that after controlling for hedging, banks' sovereign debt portfolios remain highly exposed to the market risk. Since banks consider the interest rate risk as the main source of risk, we focus our analysis on the market risk related to interest rate change. Theoretically, if banks are hedged, a simultaneous change in the IRS curve should offset the risk of a reduction in the value of securities exposed to the market risk (IRR). Figure 4 presents our hedging index, which we define as an interest rate gap, that is, the difference between interest-bearing off-balance-sheet assets and liabilities over a given period for three repricing ranges. We present a gap for each repricing period.

Long positions in off-balance-sheet items prove that banks do not hedge their long on-balance-sheet positions in debt instruments. As a result, we argue that the change in IRR should have an immediate effect on bond pricing, which will then be reflected immediately in a drop in banks' regulatory capital. Our results are consistent with those of other studies on the limited use of derivatives by banks and the strategies of hedging against interest rate risk (Begenau, Piazzesi, and Schneider 2015; Hoffmann et al. 2018; Vuillemey 2019).

7. Robustness Check

In this section, we perform a number of analyses to prove the robustness of our results.

7.1 Regression with Alternative Measures

First, we replace the tax dummy variable with the tax ratio (TAX_RATIO), defined as the total amount of levy paid by a bank in relation to the bank's assets. In line with our baseline results, we expect that banks paying higher taxes in the previous period increase their investment in government securities in the AFS portfolio. Tables 7 and 8 present regression results.

Results are in line with our baseline estimations, suggesting that fiscal incentives have motivated banks to increase the demand for sovereign debt, simultaneously reducing investment in short-term NBP bills. Just as in our baseline regressions, we find that the new investment was greater than the reduction in NBP bills (Specification (2) and (3) in Table 7), though the FA variable is statistically insignificant. Evidence from Table 8 also proves that this trend has increased banks' exposure toward AFS holdings (Specification (2)). Again, according to Specification (4), an increase in AFS securities cannot be accounted for by the substitution effect between AFS and HFT. In line with Gennaioli, Martin, and Rossi (2018), we find that banks' lending activity is negatively correlated with investment in sovereign debt, as the CREDIT coefficient is negative and

Table 7. Bank Behavior to Preferential Treatment of Sovereign Debt Securities

	FA (1)	**NBP_BILLS (2)**	**GOV_SEC (3)**
TAX_RATIO	22.30	–73.10***	90.93***
	(17.38)	(12.71)	(20.87)
SIZE(LN)	0.166	0.749	–1.203
	(1.153)	(1.121)	(1.448)
CREDIT	–0.439***	–0.213***	–0.250***
	(0.084)	(0.059)	(0.085)
DEPOSITS	0.151**	–0.001	0.123**
	(0.068)	(0.049)	(0.058)
NPL	0.152	0.180**	0.093
	(0.127)	(0.0734)	(0.165)
CET1	0.132	–0.057	0.021
	(0.135)	(0.0611)	(0.108)
ROA	–0.452**	0.001	–0.267
	(0.159)	(0.157)	(0.250)
SOV	–2.734*	4.903***	–6.420***
	(1.366)	(1.008)	(1.938)
WIBOR	0.039	0.362	–0.515
	(0.394)	(0.272)	(0.520)
GDP	0.259	0.076	0.208
	(0.200)	(0.138)	(0.139)
DEBT	0.0138	0.339***	–0.236**
	(0.136)	(0.113)	(0.109)
CDS	–0.005	–0.015***	0.009**
	(0.004)	(0.003)	(0.004)
Constant	34.65**	–5.234	46.89**
	(15.60)	(13.13)	(16.90)
No. of Obs.	662	662	662
R2	0.693	0.461	0.058

Note: The table presents the results of the GLS model with random effects and standard errors clustered at the bank level. The sample consists of all Polish commercial banks which paid the bank tax. The sample period is from 2008:Q1 to 2017:Q4. TAX_RATIO is a ratio of the amount of tax paid to a bank's net income. Financial asset is defined as a ratio to total assets; the variable GOV_SEC is defined as a ratio of government securities to total assets; NBP_BILLS is defined as a ratio of National Bank of Poland bills to total assets. ***, **, and * stand for statistical significance at the 1 percent, 5 percent, and 10 percent significance level, respectively.

statistically significant. Finally, we also confirm that stated-owned banks hold less sovereign debt than private banks, further confirming our estimations expressed in the previous subsection.

Table 8. Bank Behavior to Preferential Treatment of Sovereign Debt Securities

	HFT_SEC (1)	AFS_SEC (2)	HTM_SEC (3)	HFT_AFS_SEC (4)
TAX_RATIO	–7.375	88.66***	4.417	81.56***
	(6.038)	(21.35)	(6.385)	(18.89)
SIZE(LN)	0.074	–0.260	–0.468	–0.134
	(0.341)	(0.961)	(0.556)	(0.896)
CREDIT	–0.043*	–0.217***	–0.023	–0.260***
	(0.024)	(0.067)	(0.047)	(0.063)
DEPOSITS	–0.016	0.109**	0.006	0.095**
	(0.016)	(0.048)	(0.023)	(0.047)
NPL	0.021	0.050	–0.022	0.075
	(0.041)	(0.144)	(0.076)	(0.149)
CET1	–0.026	0.086	–0.042	0.064
	(0.023)	(0.079)	(0.046)	(0.074)
ROA	0.065	–0.468*	0.139	–0.410*
	(0.070)	(0.248)	(0.113)	(0.221)
SOV	0.618	–5.321***	0.642	–4.927***
	(0.384)	(2.061)	(0.524)	(1.823)
WIBOR	0.065	–0.695*	0.189*	–0.597
	(0.099)	(0.410)	(0.101)	(0.444)
GDP	–0.019	0.066	0.191**	0.060
	(0.078)	(0.087)	(0.095)	(0.138)
DEBT	–0.0779	–0.107	–0.0129	–0.189*
	(0.059)	(0.087)	(0.048)	(0.100)
CDS	0.001	0.007*	0.000	0.008**
	(0.001)	(0.004)	(0.001)	(0.004)
Constant	8.446	27.34**	7.009	35.17***
	(5.840)	(13.51)	(9.341)	(12.93)
No. of Obs.	662	662	662	662
R2	0.618	0.456	0.138	0.547

Note: The table presents the results of the GLS model with random effects and standard errors clustered at the bank level. The sample consists of all Polish commercial banks which paid the bank tax. The sample period is from 2008:Q1 to 2017:Q4. TAX_RATIO is a ratio of the amount of tax paid to a bank's net income. Government securities are defined as a ratio to total assets held under specific IFRS classification at banks' balance sheet: held to maturity (HTM_SEC), available for sale (AFS_SEC), held for trading (HFT_SEC). HFT_AFS_SEC is a sum of HFT and AFS holdings in relation to total assets. ***, **, and * stand for statistical significance at the 1 percent, 5 percent, and 10 percent significance level, respectively.

Table 9. Difference-in-Difference Estimations Covering Non-Tax-Paying Banks

Outcome Var:	**GOV_SEC**	**S. Err.**	**(t)**	**P > (t)**
Before				
Control	5.734			
Treated	12.037			
Diff (T – C)	6.303	0.448	14.06	0.000***
After				
Control	5.105			
Treated	17.604			
Diff (T – C)	12.499	0.897	13.94	0.000***
Diff-in-Diff	6.196	1.002	6.18	0.000***
Number of Obs.: 182				
R2 0.13				

Note: The table presents the results of the difference-in-difference model. The treated sample consists of banks which paid the bank tax, whereas the control group consists of banks which were not obliged to the tax payment, as they do not fulfill the criteria to pay the tax. The pre-regulation sample period is from 2008:Q1 to 2015:Q4. The post-regulation sample period is from 2016:Q1 to 2017:Q4. ***, **, and * stand for statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively.

7.2 Difference-in-Difference Specification

Thus far, our specification has assumed differences in banks' behavior as a result of the tax reform, mainly resulting from two-period observations: years before and after the introduction of the reform. It will also be interesting to notice whether we can reach the same conclusions confronting our sample with banks that were exempted from the tax payment. Though the difference-in-difference analysis assumes that the control group (banks exempted from paying the tax) needs to be homogenous with the treated group (banks paying the tax) (Abadie 2005), and this assumption is not fully satisfied by our control group consisting of cooperative banks, we still argue that it might give us additional information with regard to differences in banks' investment behavior as a result of the fiscal reform. Table 9 presents our estimations.

Regression results confirm our previous findings. We notice that banks affected by the reform have significantly increased their portfolio in terms of the sovereign debt, also compared with banks that have not been affected by the reform. Consequently, we conclude that tax incentives offered to banks have significantly increased the demand for sovereign debt by these banks.

7.3 Do Other Banks' Characteristics Affect Sovereign Debt Holding?

Our analyses performed thus far seem to prove that the effect of a higher demand for sovereign debt does not stem from any specific features of banks. In other words, we presume that the demand was purely financially driven, independent from any other banks' characteristics, such as credit activity or the need for an additional collateral, liquidity, or capital needs. To validate this statement, we confront banks' characteristics with the tax dummy in the following manner: loan ratio (CREDIT_TAX), liquidity (DEPOSITS_TAX), non-performing loans (NPL_TAX), banks' capital (CET1_TAX), and profitability (ROA_TAX). We expect that interaction terms appear as statistically insignificant, confirming that banks' financial situation has not affected banks' decisions regarding their government debt holdings after the introduction of the tax reform. Table 10 provides regression results while including these interaction variables.

We demonstrate that no interaction term is statistically significant. This means that the positive impact of the levy on banks' government debt holdings has not been driven by any bank's financial position or need, but it has been rather driven by the avoidance of tax payment.

7.4 Yield Curve Shock Using Alternative Simulation Methods

Thus far, we have demonstrated how the value of the debt portfolio of banks changes as a result of an arbitrary assumption of an increase in bond yields by 300 bp across all maturities. As a result, we documented that this kind of shock to the yield curve might result in significant losses for banks given their current exposure to government debt and its accounting classification. In this subsection, we provide additional robustness evidence by presenting the sensitivity of changes in the revaluation, based on three different yield curve shock simulation methods. We simulate the shock by using (i) the historical

Table 10. Alternative Motives for Sovereign Debt Holding

	GOV_SEC (1)	GOV_SEC (2)	GOV_SEC (3)	GOV_SEC (4)	GOV_SEC (5)
TAX_DUMMY	13.53	9.400***	7.340***	4.365	6.593***
	(9.609)	(2.395)	(2.378)	(2.84)	(0.969)
SIZE(LN)	–0.399	–0.48	–0.499	–0.461	–0.467
	(0.906)	(0.936)	(0.942)	(0.926)	(0.930)
CREDIT	–0.310***	–0.291***	–0.300***	–0.298***	–0.301***
	(0.067)	(0.065)	(0.067)	(0.0682)	(0.068)
DEPOSITS	0.0787	0.106*	0.0954*	0.0916*	0.094*
	(0.052)	(0.056)	(0.054)	(0.052)	(0.054)
NPL	0.072	0.089	0.083	0.075	0.070
	(0.104)	(0.129)	(0.114)	(0.127)	(0.13)
CET1	0.005	0.025	0.016	0.013	0.018
	(0.074)	(0.073)	(0.073)	(0.075)	(0.073)
ROA	–0.252	–0.283	–0.254	–0.269	–0.255
	(0.224)	(0.229)	(0.231)	(0.229)	(0.235)
SOV	–2.97	–3.711**	–3.655**	–3.789**	–3.674*
	(1.897)	(1.758)	(1.777)	(1.85)	(1.975)
WIBOR	–0.023	–0.04	–0.042	–0.043	–0.031
	(0.397)	(0.395)	(0.402)	(0.403)	(0.389)
GDP	0.299**	0.273**	0.281**	0.278**	0.288**
	(0.118)	(0.121)	(0.125)	(0.128)	(0.118)
DEBT	–0.199**	–0.227**	–0.217**	–0.213**	–0.213**
	(–0.0989)	(–0.104)	(–0.105)	(–0.102)	(–0.103)
CDS	0.004	0.005	0.005	0.005	0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
CREDIT_TAX	–0.101				
	(0.128)				
DEPOSITS_TAX		–0.051			
		(0.039)			
NPL_TAX			–0.142		
			(0.261)		
CET1_TAX				0.134	
				(0.231)	
ROA_TAX					–0.306
					(1.064)
Constant	41.79***	40.89***	41.96***	41.58***	41.63***
	(–12.53)	(–12.16)	(–12.48)	(–12.38)	(–12.38)
No. of Obs.	662	662	662	662	662
R2	0.681	0.667	0.669	0.662	0.66

Note: The table presents the results of the GLS model with random effects and standard errors clustered at the bank level. The sample consists of all Polish commercial banks which paid the bank tax. The sample period is from 2008:Q1 to 2017:Q4. TAX_DUMMY is a binary variable which equals 1 for all the periods tax is due; 0 otherwise. Variable GOV_SEC is defined as a ratio of government securities to total assets. The variables CREDIT_TAX, DEPOSITS_TAX, NPL_TAX, CET1_TAX, and ROA_TAX are defined as interaction variables of CREDIT, DEPOSITS, NPL, CET1, and ROA with the tax dummy, respectively. ***, **, and * stand for statistical significance at the 1 percent, 5 percent, and 10 percent significance level, respectively.

simulation (HS) method, as well as (ii) the Nelson-Siegel (NS) model, as compared with our standard 300 bp increase in the yield curve. The application of multiple yield curve scenario-generation methods allows us to evidence the robustness of the impact on banks' earnings as well as banks' regulatory capital, overcoming an arbitrary assumption of a parallel yield curve shift, which is of utmost importance, as "the effectiveness of a stress test directly depends on the yield-curve scenarios used in stress tests (Abdymomunov and Gerlach 2014). These methods have been widely used by regulators and/or scholars to analyze banks' exposure to interest rate shocks (Abdymomunov and Gerlach 2014; BCBS 2016).

More specifically, in the HS method we use historical yield curves to predict the potential movements of yield curves. However, as historical yields tend to be very low because of the recently observed low interest environment, as well as the quantitative easing policy, we find that historical simulation results in a number of downward-sloping curves, which generates unrealistic scenarios, i.e., it is highly unlikely that negative interest rates will go down even further. Therefore, we have decided to exclude such scenarios from our analysis and to consider only the upward-sloping curves, in line with our aim to identify potential risk of investment revaluation due to yield spikes.[7] We consider a total of four scenarios for the simulation of yield curves as a result of the historical data.

To limit the constraint of our current economic environment of low interest rates over the past decades, we also apply the NS method, as discussed by Abdymomunov and Gerlach (2014). The advantage of this method is that it enables us to produce a large variety of scenarios, based on diverse composites of shocks to the curvature, level, and slope of the yield curve tailored to the needs of our research.[8] In other words, the approach allows us to consider a non-parallel shift of yield curves. To estimate the Nelson-Siegel model, we relied on an approach similar to the one adopted by Abdymomunov and Gerlach (2014), who applied the dynamic version of the NS model developed by Diebold and Li (2006), in which the

[7] These take place when securities experience a drop in value as a result of an upward shock in the yield curve.

[8] For a list of constraints that make our simulation implausible, please refer to Abdymomunov and Gerlach (2014).

period-by-period yield curve is designed as a three-dimensional time-varying parameter. Factors are the result of time-varying autoregressive processes, leading to the Nelson-Siegel model describing the yield curve according to maturity:

$$y_t(\tau) = \beta_{1,t} + \beta_{2,t} \underbrace{\left(\frac{1-\exp(-\lambda\tau)}{\lambda\tau}\right)}_{L_2} + \beta_{3,t} \underbrace{\left(\frac{1-\exp(-\lambda\tau)}{\lambda\tau} - \exp(-\lambda\tau)\right)}_{L_3}, \tag{4}$$

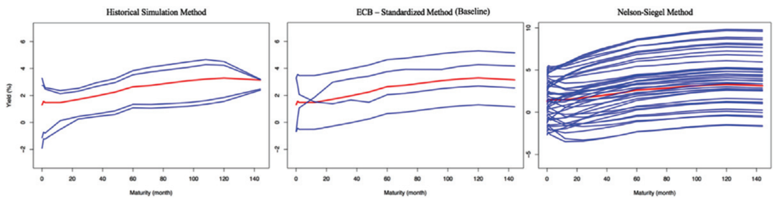
where $y_t(\tau)$ is the Polish government bond yield with maturity λ at time t. $\beta_{1,t}$, $\beta_{2,t}$, and $\beta_{3,t}$ constitute the three dynamic latent factors with specific loadings. $\beta_{1,t}$'s loading is 1, it does not decay, and therefore it might be presented as a constant long-term (LT) factor.[9] $L_2(1,\lambda)$ and $L_3(1,\lambda)$ are factor loadings for $\beta_{2,t}$ and $\beta_{3,t}$, functions of yield maturities and the λ[10] parameter. The L_2 loading on $\beta_{2,t}$ starts at 1 and quickly decays to 0 in a monotonous way, which means that it might be seen as a short-term (ST) factor—the slope of the yield curve.[11] On the contrary, the L_3 loading on $\beta_{3,t}$ starts at 0 (and, therefore, cannot be considered a ST factor), increases, and then decays to 0 (and, therefore, cannot be considered a LT factor). Consequently, it might be perceived as a medium-term (MT) factor—the curvature of the yield curve. λ is the parameter which governs the exponential decay rate; it is crucial that this parameter be properly determined. Small values of λ fit the curves of LT maturities well, whereas large values lead to a fast decay and fit ST maturities better.

[9] Diebold and Li (2006) demonstrate that the L_1 loading seems to be highly correlated with the level of the yield curve.

[10] Lambda is the parameter which governs the exponential decay rate. Small values of lambda fit the curves of LT maturities well, whereas large values lead to a fast decay and, therefore, fit ST maturities better.

[11] Consistently with Abdymomunov and Gerlach (2014) and the original NS model, we call $\beta_{2,t}$ the slope factor. Therefore, a positive value corresponds to an upward-sloping yield curve, while a negative value corresponds to a downward-sloping yield curve scenario. Given research interest in risks associated with interest rate hikes, we shall focus on positive values.

Figure 5. Yield Curve Scenarios: HS, Baseline, and NS



Source: Own estimations.
Note: The figures present the yield curve scenario according to the three applied scenario-generation methods: the historical simulation method, the standardized shock based on our baseline approach, and the Nelson-Siegel scenario-generation method.

For the purpose of our scenario generation, we can infer from the above a modification of results in parallel shifts of the yield curve based on changes in LT rates, a modification of results in changes in the slope based on shocks on the ST factors, and a modification of results in changes in the curvature, as MT maturities are mainly affected, whereas ST and LT maturity yields remain close to zero.

To generate scenarios, we follow Abdymomunov and Gerlach's (2014) approach, i.e., a two-step method: (i) we estimate Nelson parameters on historical data separately for both time periods; (ii) we build a three-dimensional grid for each factor, using a range of +/–400 basis points.[12] Drawing on these results, we calculate level factors:

$$\beta_1 = y_s(1) - \beta_2 L_2(1, \lambda) + \beta_3 L_3(1, \lambda). \tag{5}$$

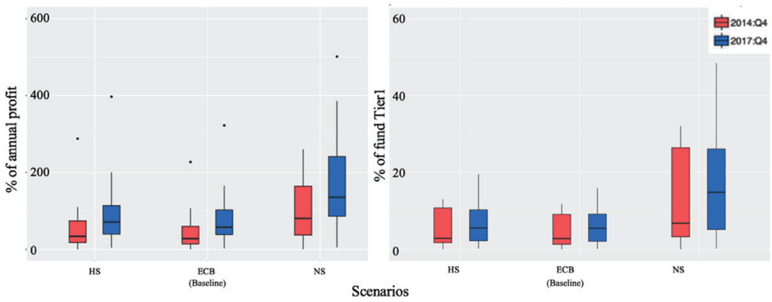
In total, we find 54 simulated yield curves.[13] Figure 5 presents the results for simulated yield curves for our two approaches, which we also confront with our baseline approach.

We notice a considerable variation within the ranges of the yield curves using different scenarios. In the NS method, the year-on-year changes are more extensive, leading to scenarios with larger ranges.

[12] +/–400 bp upward and downward yield curve shifts are recommended by the Interagency Advisory on Interest Rate Risk (2010).

[13] For more details, please contact the authors.

Figure 6. Worst Loss Scenario: Comparison of 2014:Q4 and 2017:Q4



Source: Own estimation.
Note: The figures illustrate via boxplot how the potential loss (as a percentage of a bank's profit on the left versus percentage of tier 1 capital on the right) is distributed under each of the generated scenarios on our sample banks. The left red bar represents 2014:Q4 and the right blue one represents 2017:Q4.

The NS method presents greater alterations with regard to the level, slope, and curvature. Consequently, these shock scenarios will have a greater impact on our SLIP measure. These scenarios seem to be consistent with the economic reality of central banks having the power to control short-term rates; however, forecasts shape the term premium and, thus, also long-term interest rates (Abdymomunov and Gerlach 2014).

To demonstrate the impact of diverse yield curve shocks on banks' earnings and regulatory capital, we present Figure 6, which documents aggregated potential losses from various increases in the yield curve, using our different simulation scenarios. To control for the time bias, we go a step further and compare two periods: the pre-introduction period of 2014:Q4 and the post-introduction period of 2017:Q4.

We observe that the majority of quartiles increased, pointing to the economic significance of losses. Our estimations confirm our baseline regression results, indicating that an increase in sovereign debt holdings significantly increases the market risk associated with the yield curve shock. Importantly, our regressions document that the greater the shock, the more significant the losses that banks may suffer from market revaluation.

8. Conclusion

The most recent financial crisis has emphasized the need to thoroughly understand the structure of banks' balance sheets and the impact on banks' risk exposure. Our study adds to the existing literature by testing the link between sovereign debt, the role of fair-value accounting, and associated risks.

In our study, we investigate how an increased investment in sovereign debt, encouraged by regulatory incentives, affects the structure of banks' balance sheets and, therefore, also their earnings and regulatory capital. To this end, we focus on the Polish experience. Poland introduced the banking tax on banks' assets, with preferential treatment given to government bonds. As a result, Polish banks have the highest share of domestic sovereign debt among all European countries (European Central Bank 2019). Access to the unique regulatory data on asset maturities and its accounting classification for each bank over an extended quarterly period, namely from 2008 to 2017, allowed us to investigate the risk related to this type of investment.

Our regression results evidence that banks react positively to fiscal incentives offered to them by regulators by increasing the demand for sovereign debt, while decreasing its other investments. We find a much higher impact of this reform on private banks than on state-owned banks. Interestingly, our regression results document that the regulatory incentive has also increased banks' exposure toward fair-value accounting, as banks extensively account for new investment as AFS. We argue that this is an effect of the flexibility that the AFS investment offers, additionally supported by a relatively stable environment of low interest rates.

More importantly, our regression results document that banks' increased exposure to sovereign debt under fair-value holdings increases their sensitiveness to market risk. Fiscal incentives and, consequently, banks' increased investment in sovereign debt significantly increase the SLIP variable measuring banks' losses from market debt revaluation.

We have found that a 300 bp financial shock in the yield curve might lead to losses amounting on average to more than 100 percent of banks' profits, or might reduce tier 1 capital by more than 7 percent, with a maximum loss exceeding 60 percent of the bank's capital. In the case of over 30 percent of banks, losses would be so significant that these organizations would not be able to fulfill the Basel capital adequacy ratio requirement. However, this mainly concerns banks with low capitalization that hold a significant portion of sovereign debt in their portfolio.

Our study significantly expands the existing knowledge. For many years, capital reforms have promoted government securities as part of banks' balance sheets. In our study, we investigate fiscal incentives offered to banks by Polish regulatory authorities. As this regulatory instrument is relatively new, its effect on bank behavior has yet to be examined in any published study. In addition, we analyze factors affecting banks' decisions regarding the classification of such investment. The choice of accounting policy and its impact on banks' operation has been extensively discussed following the global economic crisis of 2008–10, yet no clear conclusions have been reached. In our study, we contribute to this debate by assessing how banks determine their accounting policy, and what implications this might create for banks' operation. Finally, our contribution lies in examining the risk associated with banks' extensive investment in sovereign debt, analyzing the market risk. We believe that our contribution will be of value for policymakers. They point toward the regulation of sovereign debt holdings in banks' business either in the form of caps or additional capital requirements. Our study raises a concern about inclusion of unrealized losses in the regulatory ratios pointing toward increased banking-sector instability.

Appendix

Table A.1. Variables and Their Definitions

Variable	Definitions
AFS_SEC	Share of "available for sale" securities/asset to banks' total assets
CDS	Credit default spread for five years
CET1	Common equity tier 1
CET1_TAX	The interaction of the CET1 variable with the TAX_DUMMY variable
CREDIT	Net loans to banks' total assets
CREDIT_TAX	Interaction of the CREDIT variable with the TAX_DUMMY variable
DEBT	Country debt as percentage of GDP
DEPOSITS	Deposits to banks' total assets
DEPOSITS_TAX	The interaction of the DEPOSTS variable with the TAX_DUMMY variable
DURATION	Weighted average time until all payments from sovereign debt are settled
FA	Financial asset to banks' total assets
GDP	Gross domestic product growth rate
GOV_SEC	Government securities to banks' total assets
HFT_AFS_SEC	Sum of "held for trading" and "available for sale" assets/securities to banks' total assets
HFT_SEC	Share of "held for trading" asset/securities to banks' total assets
HTM_SEC	Share of "held to maturity" asset/securities to banks' total assets
IRRSENSITIVEBSPOSITION	Sum of fair value of debt held under AFS and HFT investment
IRRSHOCK	Shift in the yield curve based on the simulation scenarios (in bp)
NBP_BILLS	Share of National Bank of Poland bills in banks' total assets
NPL	Non-performing loans to total assets
ROA	Return on asset
ROA_TAX	Interaction of the ROA variable with the TAX_DUMMY variable
SIZE(LN)	Logarithm of total assets
SLIP_FUND	Banks' loss resulting from market revaluation of sovereign debt securities given a yield curve shock, calculated in terms of banks' capital
SLIP_PROFIT	Bank's loss resulting from market revaluation of sovereign debt securities given a yield curve shock, calculated in terms of banks' net profit
SOV	Sovereign dummy variable (1 if sovereign bank) equals 1 for state-owned banks; 0 otherwise
SOV_SEC	Share of government securities at state-owned banks to total assets
SOV_TAX	Interaction of the SOV variable with the TAX_DUMMY variable
TAX_DUMMY	Tax dummy variable (1 if paid); 0 otherwise
TAX_RATIO	Tax payment to banks' total assets
WIBOR	Warsaw interbank offered rate 3M

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